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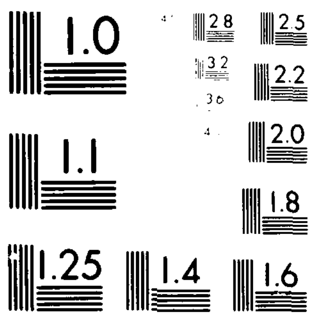

MICROCOPY RESOLUTION TEST CHART

Report No. FAA-RD-80-59

HELICOPTER TERMINAL INSTRUMENT PROCEDURES (TERPS) DEVELOPMENT PROGRAM

FINAL REPORT

JUNE 1980

Document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161.

Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Systems Research & Development Service
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16. Abstract

The Helicopter TERPS Development Program is designed to collate and coordinate all inputs received from government-sponsored and other projects which relate to helicopter TERPS in order to: assure that data generated by each project is developed, coordinated and applied in such a way as to avoid duplication of effort while achieving results in minimum time. It describes a development program whose objective is to develop criteria which will maximize the efficiency of terminal area and enroute operations with helicopters, by applying the unique maneuver-performance capabilities of helicopters. It includes both a near-term and long-term review of TERPS, both of which are expected to generate modification of the U.S. Standard for Terminal and Enroute Instrument Procedures and the criteria and procedures contained therein. The FAA, other Federal Government agencies, and organizations participating in this effort are identified. Program management responsibilities are addressed and a program schedule with milestones is presented.

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METRIC CONVERSION FACTORS

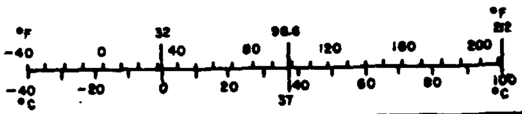
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10.286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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ABBREVIATIONS

AAT	Office of Air Traffic Service (FAA)
AFO	Office of Flight Operations (FAA)
AGL	Above Ground Level
AHS	American Helicopter Society
ARA	Airborne Radar Approach
ARN	Airborne Radar Navigation
ATC	Air Traffic Control
DH	Decision Height
DOD	Department of Defense

FAA	Federal Aviation Administration
FAC	Final Approach Course
FTE	Flight Technical Error
GPS	Global Positioning System (Navstar satellite)
HAA	Helicopter Association of America
HAT	Height Above Touchdown Zone
H-V	Height-Velocity
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
ITO	Instrument Takeoff
MAP	Missed Approach Point
MLS	Microwave Landing System
NAFEC	National Aviation Facilities Experimental Center
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NBAA	National Business Aircraft Association
NEC	Northeast Corridor
R&D	Research and Development
RNAV	Area Navigation
SRDS	Systems Research and Development Service (FAA)
STEP	Service Test and Evaluation Project (MLS)
TCA	Terminal Control Area
TERPS	Terminal and Enroute Instrument Procedures
TERPS Handbook	U.S. Standard for Terminal and Enroute Instrument Procedures (FAA Handbook #8260.3B)

USCG	U.S. Coast Guard
USMC	U.S. Marine Corps
VDP	Visual Descent Point
VLF/Omega	Very Low Frequency/Omega
VMC	Visual Meteorological Conditions
Vne	Velocity never exceed
VOR	VHF Omni-Directional Radio Range
VORTAC	Combined VOR and TACAN System

EXECUTIVE SUMMARY

Background

When Chapter 11 of the U.S. Standard for Terminal and Enroute Instrument Procedures (TERPS) Handbook was first issued in 1970, operation of civilian helicopters under Instrument Flight Rules (IFR) was not yet widespread. Only a handful of civilian helicopters were IFR certified, and those were scattered over several isolated locations. The vast majority of IFR capable helicopters were in the military and, consequently, much of the data used in developing Chapter 11 (which applies to Helicopter-Only operations) was derived from flight tests with military equipment.

Since that time, technological advances have taken place in the helicopter industry, witnessed by improved performance capabilities and an increasing number of IFR-certified helicopters available in the civilian marketplace. More recently, single pilot certifications have become relatively common. These advances in the rotorcraft industry, and the rising number of IFR-certified helicopters in actual daily operation, have combined to make this segment of the helicopter industry an element which requires renewed attention.

The helicopter has long demonstrated performance-maneuver characteristics which separate it from fixed wing aircraft. A number of those attributes can be applied during operation under instrument meteorological conditions (IMC). Among them are lower minimum IFR airspeeds and greater climb and descent angles.

The Federal Aviation Administration (FAA), recognizing that the helicopter has certain "unique capabilities," is seeking to respond to the needs and desires of the helicopter community to utilize the helicopter to the maximum practical extent in the instrument environment. The FAA also recognizes that, as helicopter technology advances, changes are appropriate in such areas as instrument procedures and criteria and air traffic control (ATC) methods.

Purpose

The Helicopter TERPS Development Program will provide the data which is needed to allow a re-evaluation of Chapter 11, and provide a vehicle for the advanced evolution of helicopter TERPS in the future. The underlying purpose of the program is to provide a plan of action which considers technological advances in the rotorcraft industry since implementation of the original Chapter 11 of the TERPS Handbook nearly a decade ago. It is intended to give credit for the improved capabilities of the current generation of helicopters, as well as prepare for inevitable future improvements in capability.

Program Goals

This program is designed to provide data to FAA's Office of Flight Operations (AFO) to support its near-term and long-term efforts to improve IFR operations of helicopters. On the near-term, it will provide data that will enable Flight Operations to respond to existing user requests for changes to TERPS and to implement early changes to Chapter 11 of the TERPS Handbook. On the long-term, the data will support Flight Operations' re-evaluation of terminal area and enroute operations and provide documentation for revisions to Chapter 11.

Technical Approach

The program will strive for near-term and long-term products suitable for use by Flight Operations in its review of helicopter TERPS procedures and criteria.

It calls for analytical validation and subsequent operational evaluation of operator/user requirements against helicopter capabilities. It establishes a methodology and framework for documenting rotary wing capabilities, as well as a measure of the adequacy of that documentation, and provides direction to data collection efforts and operational evaluation of proposed procedures and criteria.

The Helicopter TERPS Development Program is designed to collect the data necessary for later review and possible modification of TERPS by the FAA's Office of Flight Operations following analytical validation. Toward that end, this program will monitor on-going research and development (R&D) activities and utilize inputs from those various programs to satisfy data requirements for developing helicopter TERPS.

This document also identifies planned or on-going government-sponsored projects which are potential sources for data. These projects are further identified as to which data requirements they may possibly satisfy. Voids in data will be indentified and new projects proposed as necessary. Near-term projects have already been analyzed and data which will be available identified. Near-term projects are identified as those which will yield data products by the end of 1980. These will be applied to an initial review of selected TERPS areas.

As the data required for reviewing discrete areas of TERPS becomes available, it will be compared against operator requirements to determine the validity of operational requirements (needs and desires of operators). Those which are within the capability of helicopters will be the basis for recommending new procedures and/or criteria which will undergo operational evaluation. AFO will validate requirements and send data requirements to SRDS. Collected data will be returned to AFO to revise procedures.

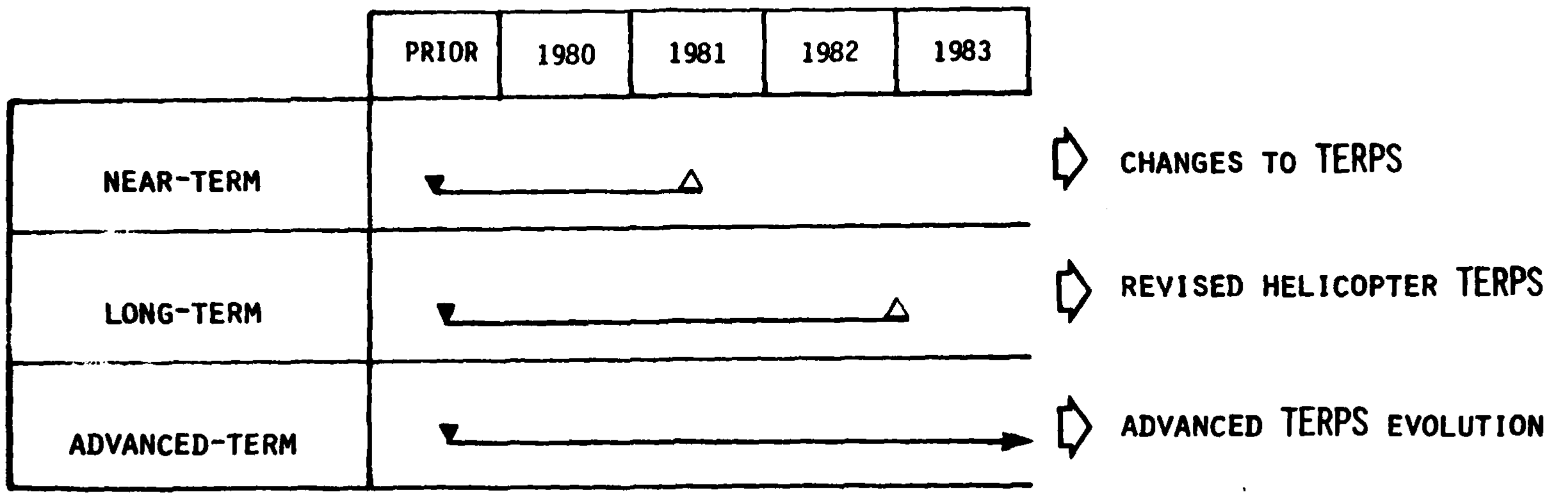
Where operational requirements can be satisfied by modifying the criteria associated with established procedures, then it is anticipated that AFO will be able to implement positive changes to TERPS. Where that approach will not suffice, then new operational procedures will be recommended. Successful operational evaluation of new procedures will result in revised helicopter TERPS that incorporate both new procedures and new criteria.

Schedule

Recognizing the continuous nature of the Helicopter TERPS Development Program, the present plan is divided into three distinct phases: Near-Term, Long-Term and Advanced-Term. The near-term is expected to result in changes to TERPS, while the long-term should allow for introduction of revised helicopter TERPS. The advanced-term considers two aspects: future validation/modification of TERPS through operational experience; and future changes resulting from the farther-reaching, high-technology endeavors of industry -- i.e., advanced concepts proposed by industry, and future developments from government sponsored, experimental programs through major facilities such as the FAA's National Aviation Flight Experimental Facility (NAFEC), and the National Aviation and Space Administration (NASA) centers at Ames and Langley. A data delivery schedule for the three phases is presented in Figure 1.

Program Management

The management of the program will be carried out by the Helicopter Systems Branch (ARD-330). Close cooperation and coordination will be maintained with selected AFO offices to ensure the suitability of data being developed for Flight Operations. The program will utilize a matrix management approach wherein various, functional groups from the Systems Research and Development Service (SRDS), Office of Flight Operations, and NAFEC will monitor the data collection efforts of specific projects and tasks.



Note: Table depicts when data from various efforts is expected to be delivered to Office of Flight Operations. Upon receipt of data, review and modification of TERPS begins for that particular phase.

Figure 1. Data Delivery Schedule.

SECTION 1
PROGRAM DESCRIPTION

Introduction

This program plan has been prepared to collate and coordinate all the inputs received from government-sponsored and other projects which relate to helicopter TERPS in order to ensure that data generated is developed, coordinated and applied in such a way as to avoid duplication of effort while achieving results in minimum time.

Essentially, the program will coordinate the activities of the different organizations engaged in a number of various projects identified in this program plan. The Helicopter Systems Branch, through this plan, intends to direct and specify additional tasks, where appropriate, to ensure a unified product with maximum results.

The overall objective of this program is to provide acceptable data to Flight Operations and Air Traffic Serice (AAT) who will develop criteria and procedures which will maximize the efficiency of terminal area and enroute operations of helicopters. Individual program efforts are being conducted to support Flight Operations in that objective, and provide them with data which will facilitate appropriate changes. This will be done by systematically examining the maneuver-performance capabilities of the helicopter, and by collating data which documents the overall "system performance" -- i.e., the interfaced man-machine and the National Airspace System (NAS).

The program seeks to provide data and a review system which will maximize the utility of helicopters operating under IMC by recognizing and applying their capabilities. It is anticipated that the greatest advantages generated by helicopter capabilities will be seen in the terminal area. It is expected that terminal procedures can be modified so as to have minimum impact on the existing ATC system, thus affording a greater degree of flexibility and utility to the helicopter community.

Background

The U.S. Standard for Terminal and Enroute Instrument Procedures contains the criteria used to formulate, review, approve and publish procedures for instrument approach and departure of aircraft to and from both civil and military airports; and it provides standardized methods for use in designing instrument flight procedures. These criteria apply at any location where the U.S. exercises jurisdiction over terminal area flight procedures and are officially adopted by the FAA and the Army, Navy, Air Force and Coast Guard (USCG). The scope of the TERPS Handbook itself is extensive, including criteria for take-off and landing minimums, missed approach procedures, obstacle clearance requirements for approaches and departures, criteria for using the various forms of approach aids, criteria for determining visibility and ceiling minimums, and enroute requirements such as feeder routes and sector altitudes. Chapter 11 (Helicopter Procedures) of the TERPS Handbook applies to "helicopter only" procedures, i.e., those "...designed to meet low-altitude, straight-in requirements only." The criteria contained elsewhere in the Handbook otherwise apply, and were developed originally with fixed wing aircraft in mind.

The FAA's Office of Flight Operations in coordination with the military services and USCG developed the criteria contained in Chapter 11 to give credit to the unique capabilities of helicopters. This was based on the premise that helicopters are approach Category A aircraft with special maneuvering characteristics. The intent of Chapter 11 is, and has been, to provide relief for helicopters from those portions of other chapters of the TERPS Handbook which are more restrictive than the criteria specified in Chapter 11.

When Chapter 11 was first issued in 1970, numerous military helicopters were operating under instrument meteorological conditions, but only two civil helicopter models were certified for IFR flight. At present, more than 10 civil helicopter models are IFR-certified, others are undergoing the certification process, and most future helicopters are expected to be offered by manufacturers IFR-certified "off-the-shelf". This has

been the result of operator demand and some industry estimates suggest that the number of IFR capable helicopters operating in the United States may number well into the thousands in the 1980s.

Subsequent to the creation of Chapter 11, the FAA has made numerous regulatory changes to aid the interim development of helicopter IFR operations. As the state-of-the-art of the helicopter industry improves, TERPS may continue to be revised to permit greater latitude in helicopter IFR operations. Industry requests generally have been based on the unique capabilities of helicopters, and typically have included such requests as: reduced landing and takeoff minimums, less restrictive alternate minimums, steeper approach angles, revised obstruction clearance gradients, relaxed weather reporting criteria, and more.

In an effort to respond to these requests and generate meaningful improvements to TERPS, the FAA is systematically examining and documenting the capabilities of current, IFR-capable helicopters and their operation in the NAS to develop the data required to implement changes to TERPS. At the same time, organizations like the Helicopter Association of America (HAA) and the American Helicopter Society (AHS) are making continued contributions through committees and operator/member working groups.

When addressing the operation of helicopters under IMC within the NAS, there is one particular segment of that airspace system that is readily identified as being critical, with significant impact on operational profiles: the terminal environment. The terminal environment typically is a highly structured airspace that includes high-density Terminal Control Areas (TCAs), light and medium-density airport traffic areas, and discrete heliports. As the helicopter becomes more and more integrated into the IFR operational environment terminal operations foreseeably may include a number of remote traffic areas suitable only for helicopter use. With that understanding, it becomes vital that terminal procedures especially be addressed thoroughly and with great care.

Technical Approach

This program will strive not only for near-term improvements to present terminal operations, but will also include efforts toward long-term recommendations for future improvements. Close coordination will be maintained with those research and development agencies identified, and their projects, to avoid duplication, to benefit from their results, and to supplement them where appropriate to yield the highest quality product from the program.

The program involves the documentation and analytical validation of three elements: the parameters currently specified in the TERPS Handbook, helicopter capabilities, and operator requirements (needs and desires). Requirements which are not already within the TERPS Handbook parameters will be compared against helicopter capabilities. Those not within the capabilities will be addressed in Advanced-Term efforts designed to respond to future advances in helicopter technology.

Those requirements that are within current helicopter capabilities will undergo operational validation in near- and long-term efforts. Where changes in criteria only can satisfy operator requirements, a near-term validation of recommended modifications will be made. The revised criteria will be used with existing procedures. Where current procedures need to be altered, then new operational procedures will be developed and evaluated. The latter is a long-term effort which would lead to implementation of revised helicopter TERPS (both procedures and criteria).

Schedule

The activities addressed in the Technical Approach Overview are depicted in Figure 1-1, which presents major milestones for the program. It should be noted that the documentation of helicopter capabilities will provide continuous outputs in an effort to deliver the most current data base achievable to Flight Operations. As information is developed during

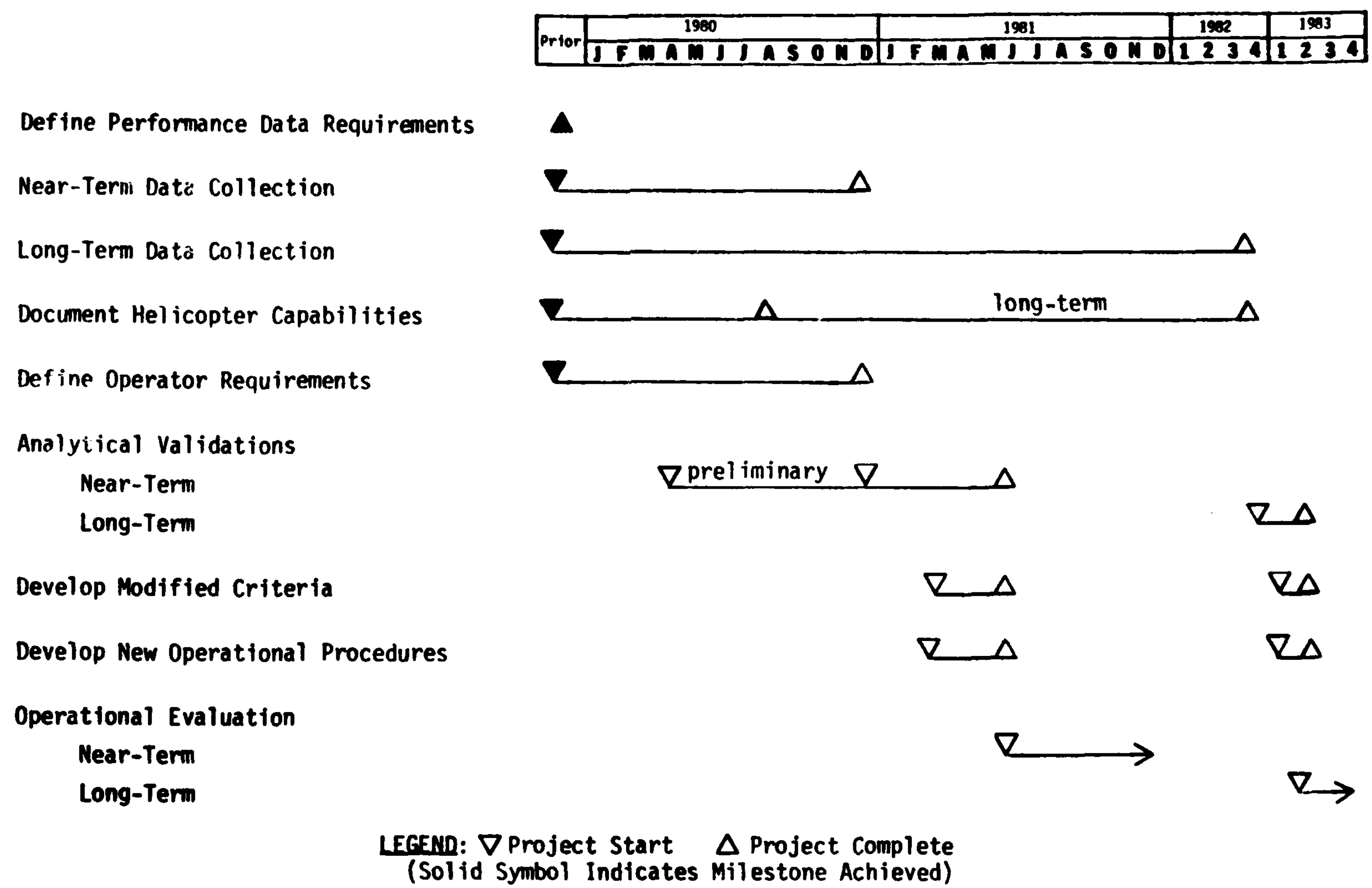


Figure 1-1. Major Program Milestones

that documentation effort it will be reported to Flight Operations to allow for the earliest possible impact on helicopter operations.

Program Management and Interagency Participation

The Helicopter TERPS Development Program has been designed to support Flight Operations in its efforts to modify TERPS. The data collection efforts will be coordinated by the Helicopter Systems Branch (ARD-330). The appropriate AFO offices will apply program data and initiate appropriate changes to helicopter instrument procedures.

Operational needs and desires are received by AFO from the helicopter community, FAA's Helicopter Task Force, and various government and civil TERPS committees. Appropriate AFO offices define these as operational requirements prior to giving them to SRDS. Helicopter Systems Branch (ARD-330), coordinates the gathering of data. Close coordination will be maintained with AFO personnel to assure that the data developed is suitable for later reduction, analysis and application by AFO.

Extensive interaction and cooperation will be accomplished with NASA, the military services and the civilian helicopter community. Joint projects being conducted by FAA/NASA and FAA/Army will be closely monitored and coordinated regarding progress, data acquisition and analysis, alteration of objectives to meet the needs of the total program, and updating of requirements.

In an effort to satisfy the requirement for close coordination and interaction between the FAA and other government agencies, the Helicopter Systems Branch will maintain liaison throughout the course of the program with Department of Defense (DOD), NASA-Ames, civilian operators, and the Coast Guard. Figure 1-2 depicts the program management and data flow process, and Table 1-1 shows management milestones for the program.

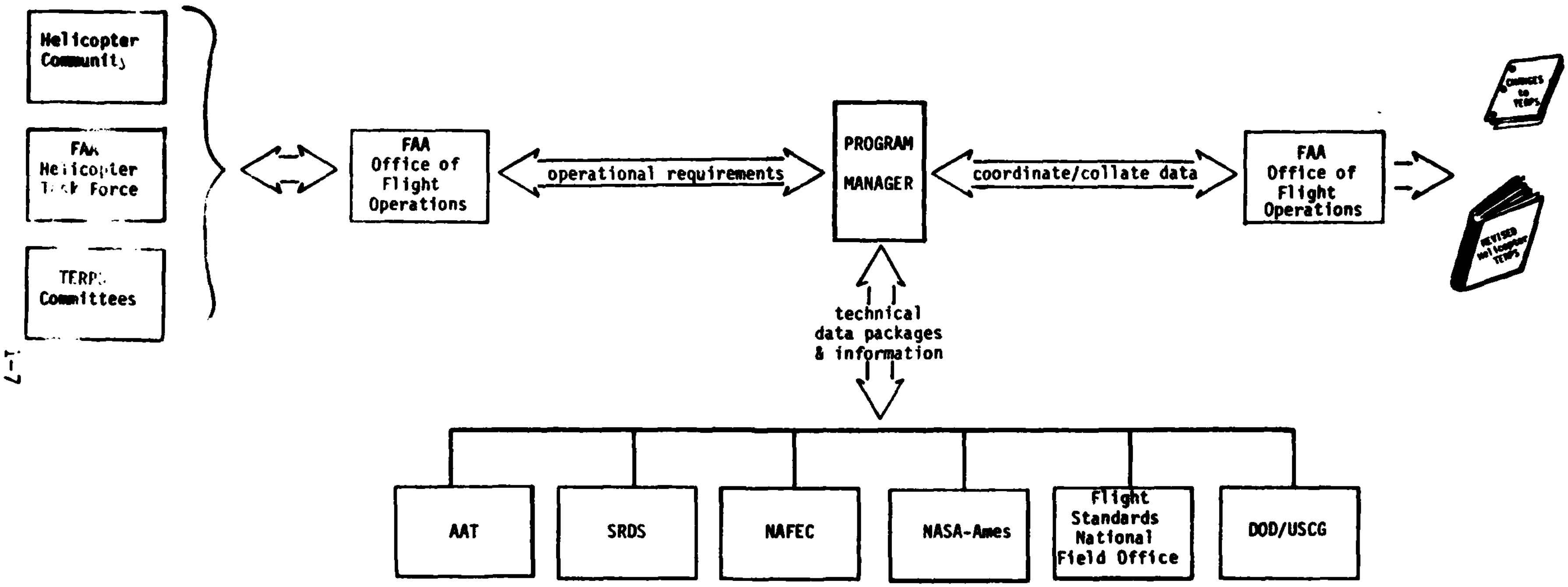


Figure 1-2. Program Management and Data Flow.

TABLE 1-1

MANAGEMENT MILESTONES

Date	Milestone
Mar 1980	Meet with facility liaison personnel and selected project managers to confirm sources for specific data requirements; modify existing test plans as appropriate.
Mar 1980	Prepare initial flight test plans.
Apr 1980	Summary Report of approach/departure performance of IFR certified helicopters.
Jun 1980	Begin initial flight tests with light, medium and heavy helicopters using basic flight instruments and conventional approach aids.
Jun 1981	Complete Near-Term data collection.
Jul 1981	Begin Long-Term operational evaluations.
Jun 1983	Begin advanced operational evaluations.

SECTION 2
TECHNICAL APPROACH

Introduction

Much of the criteria and procedures for terminal area operation of IFR helicopters were developed based on a history of fixed wing experience. In the past, those fixed wing criteria evolved through long-standing practices which became accepted because they have been proven over a significant period of operational experience and use.

That is not the case with helicopters. The desire by industry to depart from standing operational procedures is based on the fact that helicopters are different than airplanes -- in many situations, more capable; in others, less capable (such as range). To depart from accepted procedures based on "unique capabilities" carries with it a tremendous responsibility. That responsibility is to maintain a level of safety for those aircraft, while at the same time helping to promote the growth of an industry.

With the emergence of helicopters as a prominent segment in the IFR arena, a more precise approach to developing helicopter procedures and criteria must be introduced. And this is for the very reason that the helicopter industry has sought to change TERPS -- because the helicopter has "unique maneuvering capabilities" unlike fixed wing, and thus does not fit the existing mold of aircraft operating in the terminal and enroute environment.

The helicopter has long demonstrated a different level of capability when compared to fixed wing aircraft. Some examples of those differences include: a range of various takeoff profiles to include the ability to takeoff and climb vertically; when landing to a runway, the helicopter is not committed to touchdown in a certain segment of a paved runway; the helicopter can land in relatively unprepared clear spaces in remote areas that totally exclude fixed wing traffic; helicopter airspeeds range from zero to a Velocity Never Exceed (Vne) of 100-200 mph.

But those capabilities primarily impact operations under visual meteorological conditions (VMC). The uniqueness which is applicable specifically to Chapter 11 of the TERPS Handbook, and to operations under IMC in general, are less obvious.

The helicopter under IMC, unlike the majority of fixed wing airplanes: can maintain descent gradients of more than 10 degrees under no wind conditions; can operate at lower minimum IFR airspeeds (typically 40-60 knots); needs less airspace when operating in its slow speed flight regime because of reduced turning radii; has greater acceleration and deceleration rate capabilities; can usually sustain climb angles of greater than 10 degrees; and has direct lift response to power changes.

All except the first item (descent gradients) have considerable impact on missed approach performance. But foresight dictates that thought must also be given to future technological advances which will surely improve helicopter capabilities further.

The reference to a VMC capability of operating through zero airspeed underscores the helicopter's ability to operate throughout the back side of the power curve. This VMC ability to operate at speeds less than the present minimum IFR airspeeds has already been coupled experimentally with autopilots to achieve decelerating approach capability. This offers potential in the foreseeable future for significant advances in helicopter TERPS.

Although differences exist between performance characteristics of helicopters and airplanes, any helicopter-specific procedures and criteria which are developed, must also be compatible with the existing NAS. This raises several crucial questions in developing helicopter TERPS. How extensively should special helicopter procedures be implemented? How capable is the helicopter of mixing with fixed wing traffic? Further, can it cope with fixed wing approaches?

The lower minimum airspeeds give helicopters much of their uniqueness when compared to fixed wing. However, without the lower end of its airspeed envelope, much of the helicopter's uniqueness disappears. Yet under all conditions, the helicopter approach and enroute airspeed envelopes compare favorably with much of conventional fixed wing traffic. By direct comparison, all IFR-certified helicopters can tailor approach speeds to be compatible with either approach Category A or B airplanes.

Thus, the helicopter can easily mix with fixed wing traffic and cope with fixed wing approach procedures, yet remains capable of executing distinctly different procedures when necessary. The extent to which special helicopter procedures are implemented will be determined in part by the needs, and level of activity, of the IFR helicopter community.

Technical Approach Overview

The overall objective of the program, as stated earlier, is to develop criteria and procedures which will maximize the efficiency of terminal and enroute operations of helicopters. The technical approach thus involves defining, then comparing, the applicable performance capabilities of helicopters against procedures (existing and proposed); validating the suitability of those prodecures; and developing operational procedures which would allow improved utilization of helicopter capabilities.

An overview of the technical approach is presented in Figure 2-1, and depicts the flow of activities. Note that it requires the definition and documentation of three elements of the TERPS problem: TERPS parameters (from the TERPS handbook); current helicopter performance capabilities; and the operational requirements (needs and desires) of operators in the helicopter community.

Analytical validation of those elements will first identify operator requirements that are not presently within the allowable parameters of the

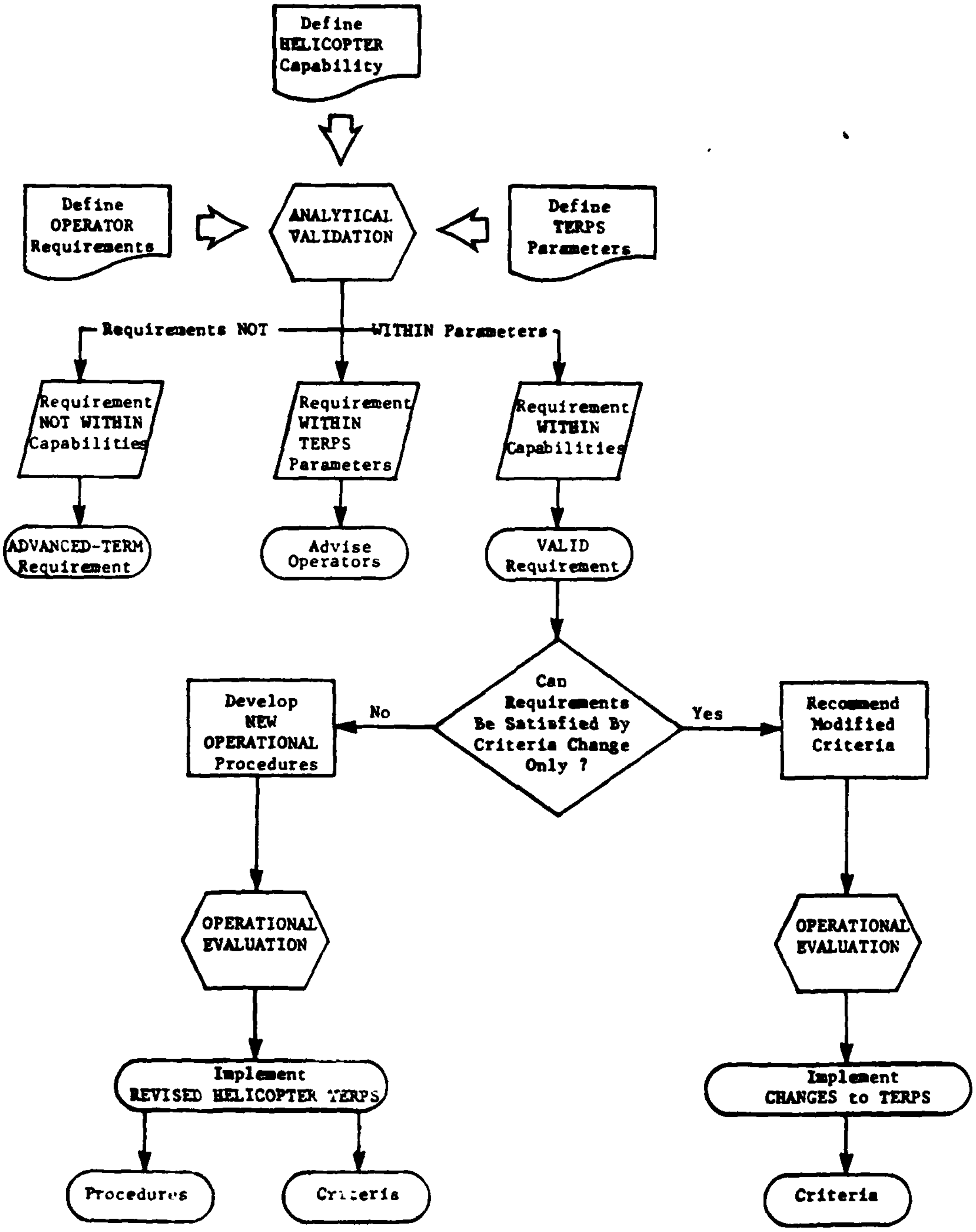


Figure 2-1. Technical Approach Overview.

TERPS Handbook. Second, it will determine the validity of those requests based on whether or not they are within the current capabilities of helicopters.

Those requirements that are within current helicopter capabilities will undergo operational evaluation in near- and long-term efforts. Where changes in criteria only can satisfy operator requirements, a near-term evaluation will be made of recommended modification of criteria to be used with existing procedures. Where current procedures need be altered, then new operational procedures will be developed and evaluated. The latter is a long-term effort which would lead to implementation of revised helicopter TERPS (both procedures and criteria).

Those requirements that are not within current helicopter capabilities will be addressed in advanced-term efforts designed to respond to future advances in helicopter technology. These requirements will be periodically reviewed and, as advances are made in airframe and avionics technology, analytical validation will identify those requirements then within helicopter capabilities.

Operational Environment

Before discussing the methodology of this program in any detail, the basic helicopter IMC operating environment should be defined. This will establish the framework for data acquisition and provide a common reference against which operator requirements can be defined, helicopter capabilities can be documented, and existing helicopter TERPS can be portrayed. This affords a common ground for later comparison of those three key elements of the Helicopter TERPS Development Program.

Figures 2-2 through 2-4 depict a composite helicopter IFR flight profile, and identify the operational flight phases applicable to terminal area and enroute operations of helicopters, in both a profile (Figures 2-2, 2-3) and plan view (Figure 2-4). It represents a reasonable operational

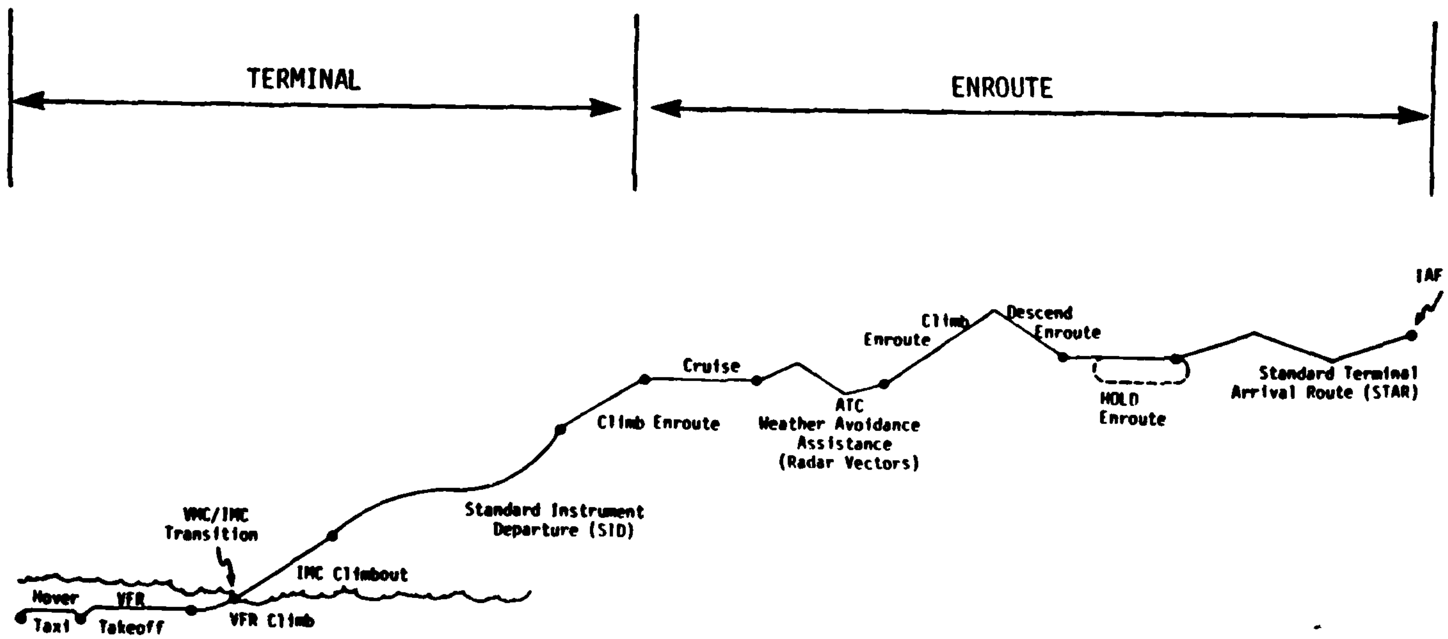


Figure 2-2. Composite Helicopter IFR Flight Profile (Departure and Enroute).

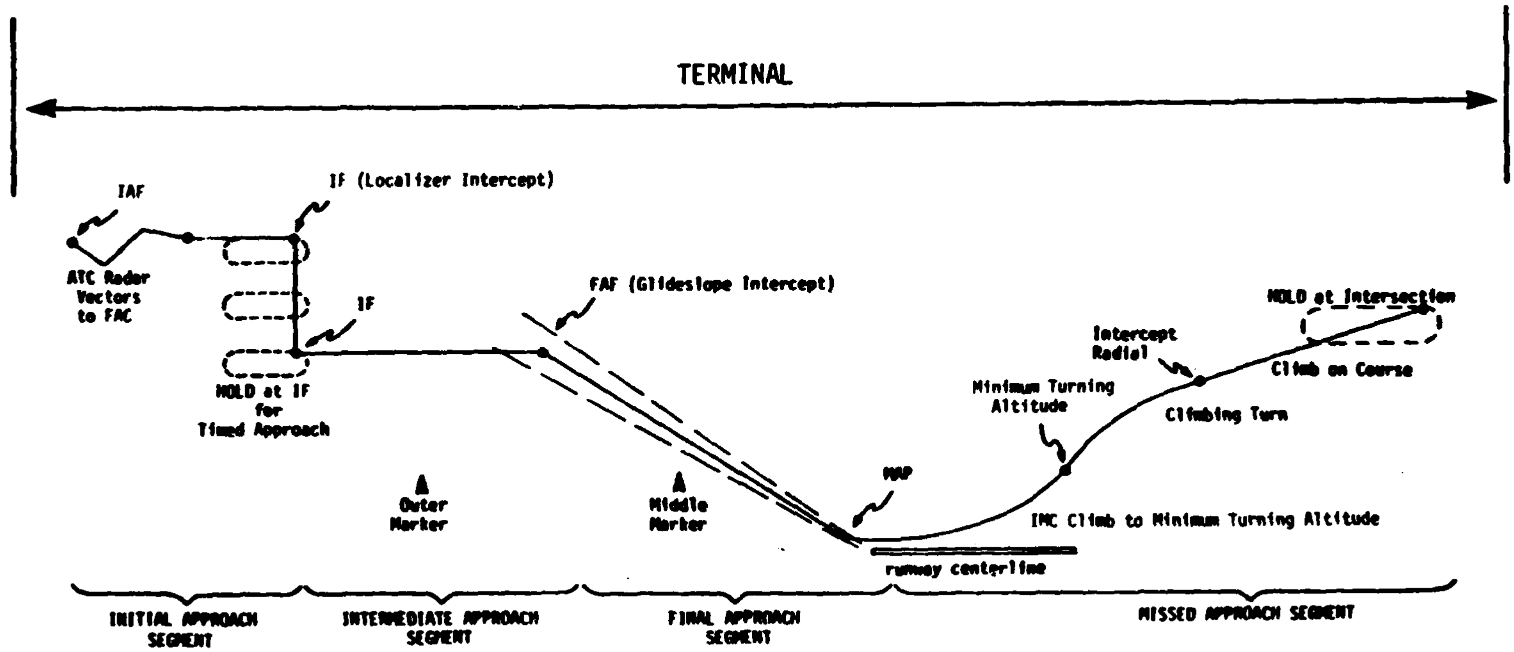


Figure 2-3. Composite Helicopter ILS Approach Profile (Approach and Missed Approach).

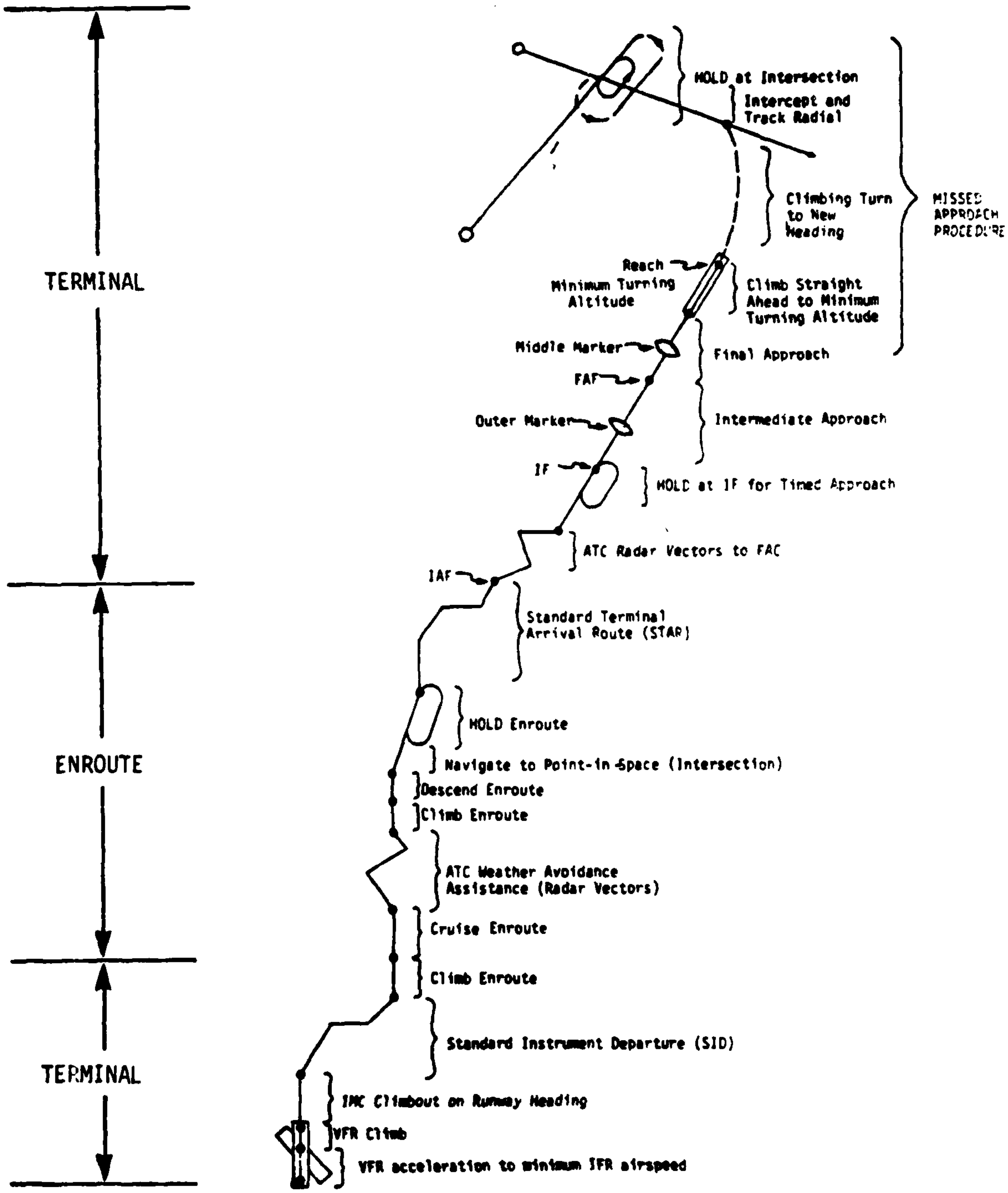


Figure 2-4. **Composite Helicopter IFR Flight Profile (Plan View).**

definition for flight under IMC, and identifies the basic events which a helicopter must be prepared to contend with during IFR flight. Shown is a precision approach, presently considered to be the most demanding. But the options for different types of approaches on arrival are numerous, including non-precision approaches with minimum descent altitudes and procedure turns. Scenarios will be composed to define a number of alternatives against which helicopter capabilities will be compared and to defne the needs and desires of operators.

Data Requirements

As stated earlier, the Composite Helicopter IFR Profile establishes the framework for data acquisition. That operational flight profile can be divided into eight discrete areas of terminal and enroute operations:

- Takeoff and Takeoff Minimums
- Departure
- Guidance System Accuracies (Enroute/Approach)
- Procedure Turn/Holding Areas
- Approach Areas and Segments
- Landing Minimums
- Missed Approach
- Visual Approach Segment

Each discrete area involves separate TERPS procedures and criteria, resulting in distinctly different data requirements. For example, data requirements in the Departure area would include climb performance, Approach Areas and Segments would include descent performance, and the Missed Approach area would go beyond climb performance considerations to include such items as height loss during go-around and the longitudinal distance required to establish a stable climb profile. Before any changes or revisions to helicopter TERPS can be made, those and other data requirements must be met.

Beyond the specific requirements which determine the procedures and criteria in each of the discrete areas, there are a number of general, performance-oriented factors which affect all data acquisition efforts. They include such items as density altitude and relative wind. The impact on helicopter performance, and consequently TERPS, of these and other factors must also be documented. To allow for factors such as those, which generally affect helicopter performance, another discrete area will be addressed:

- General Performance Factors

The data requirements for each discrete area are presented in detail in Section 3. It provides a checklist of performance and operational considerations which must be documented to allow further changes to TERPS.

Methodology

The principal method of accomplishing this program will be to develop detailed documentation of helicopter capabilities to enable the responsible AFO offices to modify TERPS as they pertain to helicopters. The documentation efforts will strive to provide the data requirements specified in Section 3 of this program plan.

Operator requirements will be identified in terms of operational profiles compatible with other documentation to facilitate their comparison with TERPS and helicopter capabilities. Subsequent recommendations for modified procedures and criteria will undergo appropriate operational testing and evaluation.

A more detailed discussion of the major elements of the technical approach depicted in Figure 2-1, and a general discussion of the methodology to be applied in each process, follows.

Definition of TERPS Parameters

Largely, criteria contained in the TERPS Handbook have been presented in terms of descent and climb gradients (slopes which provide obstacle clearance), minimum descent altitudes and decision heights, visibilities, etc. Criteria will be depicted in such a way as to be compatible with the documentation of helicopter performance capabilities for later analytical validation of requirements.

Some criteria will be depicted using graphs, such as the descent gradients specified in the TERPS Handbook for 400, 600, and 800 feet per nautical mile (normal, optimum and maximum permissible, respectively). Other criteria may lend themselves to more pictorial presentations similar to those currently used in the TERPS Handbook, such as missed approach procedures and criteria.

Definition of Operator Requirements

Operator requests for change, and the needs and desires perceived by them as requirements, are expected to cover a broad spectrum of operational statements. When IFR flights are conducted, much of the composite IFR flight profile presented earlier will be applicable. The major differences will be in the departure and approach/landing segments.

To develop a definition of operator requirements, segments of that IFR profile will be used where appropriate in developing an Operations Model. Those segments that do not apply will be modified to establish a flight profile which depicts the general operational requirements. A narrative will summarize the conditions and activities required for that segment to include anticipated lighting and marking considerations on breakout, and the flight control and auxiliary tasks the pilot must be expected to contend with. Quantitative requirements desired by operators, such as takeoff and landing minimum needs, will be separately noted. These might include such items as minimum decision height, visiblility, and glideslope angle. These

will be presented in tabular or graphic format to be compatible with the earlier definitions of helicopter capabilities and the TERPS Handbook parameters.

Definition of Helicopter Capabilities

Any attempt to change the procedures and criteria for instrument operations of helicopters requires a comprehensive understanding of their capabilities, and how they impact TERPS. Further, any implementation of changes requires a thorough documentation of both capabilities and limitations if an appropriate level of safety is to be provided.

The documentation of helicopter maneuver-performance capabilities will combine two types of data: that obtained from a review of published performance data pertaining to current helicopters; and statistical data derived from a number of on-going and planned flight and simulation projects identified in the Appendix.

Flight and simulation projects to collect statistical data will generate two different types of data: Helicopter Performance and NAS/Helicopter Performance. The first provides data on the man-machine, maneuver-performance capabilities of the various helicopters utilizing the instrument environment. The second yields the combined performance capabilities of the NAS and helicopter together, and includes a variety of ground-based navigation and approach systems. These experiments are designed to obtain statistical, real-world, performance data for obstruction plane/airspace criteria development and will also allow documentation of helicopter capabilities to a greater extent. Of importance to near-term efforts to improve TERPS, there will be continuous data outputs for the duration of these experiments. Data will be coordinated with, collated and delivered to Flight Operations for reduction, analysis and application. As specific data on the operational capabilities of helicopters becomes available, it also will be forwarded to Flight Operations to provide a continuous flow of data in the efforts to document helicopter capabilities.

As helicopter capabilities are documented, and the data requirements from Section 3 are met, appropriate parts of the discrete areas can begin the analytical validation process. Capabilities will also be documented in such a way as to define the full range of capabilities and limitations, as a group or sub-groups where appropriate. This will be useful in later investigation of helicopter landing categories.

Analytical Validation

This initial validation process will compare the three definitions developed in the preceding paragraphs: operator requirements; parameters of the TERPS Handbook; and helicopter capabilities. The validation itself will be done in two phases.

The first phase will compare operator requirements with current TERPS and determine if they can be satisfied by applying existing procedures and criteria contained in the TERPS Handbook. Those that can will be so noted, and operators will be advised. Those that cannot be established using existing TERPS, will proceed to the second phase of validation.

The second phase will compare operator requirements against current helicopter capabilities. Those requirements that fall WITHIN the performance envelope of helicopters will be considered valid requirements.

Finally, a determination will be made as to whether or not the requirements can be satisfied with only a criteria change to existing procedures.

Recommending Modified Criteria

If a criteria change alone can safisfy a requirement, then modified criteria will be recommended. An example of this would be when an existing procedure (such as a turning missed approach) is still applicable, but only a change in criteria (such as the obstacle clearance area radius) is needed to satisfy the requirement.

Developing New Operational Procedures

Where requirements within helicopter capablities cannot be satisfied by only changing existing criteria, then new operational procedures must be developed. In this case both procedures and criteria will be formulated, where significant capabilities have been identified, in an attempt to further maximize the utility of helicopters. These may include procedures developed around existing navigation and approach aids and procedures, the use of existing aids in combination, or perhaps development of entirely new procedures using new concepts and equipment.

Care will be taken when developing new procedures, with special consideration for the general performance factors discussed in Section 3. Although a requirement may be within the performance capbilities of the helicopter, it may not readily lend itself to formulation of a procedure which utilizes it. An example of this might be formulating an approach procedure that utilizes steep descent gradients, which would be fully within the performance capability of a group of helicopters; but when applied in combination with a procedure turn which culminates by intercepting a localizer, it may generate such a high level of workload that the performance level which can be achieved could be unacceptable. Where this is considered to be a possible factor, it will be identified as a specific test requirement in the operational evaluation process.

Operational Evaluation

Once procedures and/or criteria have been formulated, they will undergo an operational evaluation which will be conducted at two levels: simulation and flight. Simulation will be applied wherever it is appropriate for preliminary investigation of proposed precedures. Flight evaluations will be conducted wherever additional documentation is required, and may be done under SFAR 29 or through discrete programs such as FAA flight test projects at NAFEC or other locations.

Evaluation of new procedures will document total system accuracy as well as performance. It will assess the combined accuracy of man-machine, maneuver-performance capabilities, the navigation and approach aids, the ATC system, etc.

Implementing Changes and Revisions to TERPS

Where recommended criteria and new procedures are successfully evaluated, modifications to terminal and enroute instrument procedures can be recommended. Changes will be proposed to modify criteria for current procedures in the TERPS Handbook. Where new operational procedures are to be applied, revisions to the TERPS Handbook will be proposed. The responsibility to coordinate and publish recommended or proposed changes or revisions to TERPS will remain with AFO.

Advanced-Term Requirements

In the course of the analytical validation process, it is possible that not all operator requirements will be within current helicopter capabilities. Those requirements which are in that category were identified as Advanced-Term Requirements. They will be systematically reviewed, and as requisite technological advances occur in airframe, avionics, etc., a test program will be undertaken to determine whether an advanced capability can satisfy the requirement.

SECTION 3

DATA REQUIREMENTS FOR HELICOPTER TERPS

Introduction

The FAA has received various requests from the helicopter community for changes to terminal and enroute instrument procedures. But before undertaking any wholesale revision of TERPS, and before responding to the more innovative requests from industry, a number of important data requirements must be met. This section identifies those data requirements which must be documented to allow further changes to TERPS.

The Composite Helicopter IFR Profile presented in Section 2 established a framework for data acquisition. It was divided into eight "discrete areas" of terminal and enroute operations, and one general performance area, each of which is addressed in this section. Those discrete areas are:

- Takeoff and Takeoff Minimums
- Departure
- Guidance System Accuracies (Enroute/Approach)
- Procedure Turn/Holding Areas
- Approach Areas and Segments
- Landing Minimums
- Missed Approach
- Visual Approach Segment
- General Performance Factors

It should be re-emphasized here that General Performance Factors were included to allow for factors which generally affect helicopter performance throughout the other discrete areas. It is addressed separately at the end of this section.

The discrete areas are addressed individually here to allow for a more timely response to specific industry requests for change. In this way, when the data required to document an area has been received, and the

reduction and analysis of that data completed, it can be applied for an early modification of existing TERPS. This will facilitate more immediate improvements to helicopter instrument operations.

General

It should be noted from the outset that the procedures and criteria in the TERPS Handbook are developed to provide obstacle clearance and weather minimums, including lighting and marking requirements.

The TERPS Handbook has traditionally addressed only those operations under IMC, and has not concerned itself with the visual segments, i.e., those flight segments conducted under visual meteorological conditions. When developing procedures and criteria for airplanes that are taking off from or landing or a runway, the ability to satisfy the takeoff and landing objectives (VMC requirements) is not in question. However, helicopters have the ability to takeoff and land vertically and typically do not operate to and from runways.

Because of these VMC-unique capabilities, certain aspects of operations under VMC must be considered for helicopters. The procedures and criteria in the TERPS Handbook allow instrument approaches to be developed which deliver a helicopter to a missed approach point (MAP) from which an approach and landing is to be executed under VMC. If the ultimate objective is landing, then the point to which the helicopter is delivered should place the helicopter in a position from which that objective can be successfully met. For fixed-wing aircraft, delivery to the threshold of a runway, and more recently to a visual descent point (VDP), minimizes the need for any great concern with visual segment requirements. But the requirements for helicopters can be more complex.

It is important, then, that several subject areas be introduced in developing helicopter TERPS. The requirements for transition to and from VMC are discussed under General Performance Factors. The operational requirements under VMC are discussed under the Visual Approach Segment discrete area.

Data requirements for each discrete area are generally grouped into three categories: lateral, vertical, and special requirements (peculiar to the discrete area in question). Data common to all discrete areas for lateral and vertical airspace requirements are developed through the determination of system accuracy in the Guidance System Accuracies discrete area.

Takeoff and Takeoff Minimums

The data requirements for this discrete area are expected to answer several questions crucial to developing helicopter TERPS. What is the minimum visual segment required for takeoff? Where does the takeoff run end and the IMC segment start? What takeoff minimums are appropriate for helicopters? What are the obstacle clearance requirements for takeoff? To answer those questions, the following subject areas require data acquisition:

TAKEOFF GROUND DISTANCE must be determined based on both acceleration and deceleration distances for selected airspeeds. Specific data requirements which apply include the distribution of acceleration distances and initial climb gradients to determine their impact on takeoff.

CLIMB PERFORMANCE ENVELOPE gradients should be considered for appropriate gross weights and selected density altitude (DA) conditions as they affect obstacle clearance. Also, initial climb gradients must be determined for selected airspeeds. Appropriate obstacle clearance requirements for the takeoff area must also be established for helicopters. Presently the

obstacle clearance requirements for fixed wing are established at 35 feet for turbojets and 50 feet for propeller driven.

IMPACT OF TAKEOFF PROFILES must be evaluated with respect to near-vertical (jump-type) and acceleration-type instrument takeoffs (ITOs). This should include operational definitions of both types of takeoff profiles, and reviewing VMC/IMC transition airspeed requirements and any Height-Velocity requirements that may be applicable. The two types of takeoff must be analyzed to determine their applicability to civilian operations and recommended takeoff profile scenarios developed as appropriate.

VISIBILITY REQUIREMENTS must be determined in terms of takeoff ground distances developed above, and the ability to see and avoid obstacles considered.

VISIBILITY CREDITS for takeoff, although not currently used, could provide noticable relief for heliports and impact the more remote departure areas. Appropriate credits should be developed after determining the applicability of credits for lighting and marking, and recommending standards for applying those credits.

Departure

The departure area begins with the point of VMC/IMC transition and ends when the helicopter is delivered to the enroute phase. It specifically includes the initial climb profile at the time of transition to IMC. The subject areas requiring data acquisition for this discrete area center on climb performance and the impact of the point of earliest effective course guidance.

CLIMB PERFORMANCE ENVELOPE is equally important to the departure area as it is to takeoff and takeoff minimums. Because departures can involve both straight and turning procedures, the application of climb performance data will be concerned largely with climb gradients for selected airspeeds

in both straight and turning climbs. Of special importance here will be documenting the effect of turning maneuvers on those climb gradients by considering such interdependent factors as power available and density altitude, angle of bank, and airspeed as they affect rate of climb.

DEPARTURE PROFILE ANALYSIS will review an initial departure profile and plan view for both straight and turning departures with respect to ground track and climb gradients. Minimum height above ground level (AGL) must be established for turns to facilitate development of earliest turn track and latest turn tracks in the profile. Climb profiles for selected airspeeds in turning flight will also be developed to identify effects on climb gradients.

EARLIEST POINT OF EFFECTIVE COURSE GUIDANCE is particularly important here, especially its impact on the early moments of climbout from the takeoff area. Also, lateral flight technical error prior to guidance during the initial climb is important. This data can be derived from the Guidance System Accuracies discrete area.

Guidance System Accuracies

This discrete area calls for the documentation of system accuracy for application to all phases of IFR profile discrete areas as appropriate, in terms of lateral and vertical position accuracy. Guidance system accuracies will be confirmed or developed as required for both enroute and approach systems. Where the potential exists for approach applications of systems previously considered enroute aids only, the suitability for approach use will be investigated, e.g., INS and Loran-C. System accuracy is a combination of three types of error: ground system error (from ground-based navaids or approach aids), flight technical error (from the man-machine), and the airborne system error (from on-board equipment and components).

GROUND SYSTEM ERROR must be known for such navigation and approach aids as: ILS, MLS, VOR, DME, NDB, Loran-C, VLF/Omega, GPS, and airborne radar if it is to be used as a navigation (ARN) or approach (ARA) aid.

FLIGHT TECHNICAL ERROR (FTE) must consider the impact of such factors as: tracking error versus various descent angles and rates of descent, aircraft performance-maneuver capabilities, aircrew manning levels, and instrumentation/display (i.e., whether raw or computed data is presented to the pilot).

AIRBORNE SYSTEM ERROR will also address aircraft instrumentation, but at a different level than the instrumentation/display included in the investigation of FTE. Airborne system error is that error which develops between the antenna and the face of the instrument, i.e., the error associated with the airborne receiving equipment and other components. It will also consider rotor modulation effects on navigation and approach aids. With regard to consideration of instrumentation/display, this level involves the error in getting the data to the instrument, whereas the flight technical error considers the errors resulting from pilot interpretation and application of the data as it was presented.

POINT OF EARLIEST EFFECTIVE COURSE GUIDANCE should be identified for each of the navigation and approach aids addressed in groundborne error. This data will be applied to other discrete areas where appropriate.

Procedure Turn/Holding Areas

The subject areas requiring data acquisition in this discrete area include: both lateral and vertical airspace requirements, and the evaluation of holding patterns and procedure turns. An investigation of the special impact of relative wind should also be undertaken.

LATERAL AIRSPACE REQUIREMENTS involve radius and rate of turn relative to angle of bank and airspeed. Maximum bank angle must be established in terms of an absolute maximum as well as investigation of any requirements that may be necessary in determining a turning rate standard appropriate to helicopters. These angles must also be understood as they are impacted by different flight conditions, i.e., level and descending flight versus

various selected airspeeds which might be used during terminal operations. The effect of density altitude on airspace requirements will also be investigated as it affects true airspeed and actual turning radius. Lateral airspace requirements must also be determined for entry phase maneuvers. This will apply to selected, optional entries (including potential proposed ones) for both holding patterns and for procedure turn areas.

VERTICAL AIRSPACE REQUIREMENTS depend largely on altitude control and descent gradients. The ability to maintain an altitude will be affected by airspeed, angle of bank, and other factors. Airspace requirements will also be affected by aircraft descent performance, which will tend to place limits on the descent gradients which can be achieved.

EVALUATION OF PATTERNS AND TURNS will necessitate application of system accuracy data obtained in the Guidance System Accuracies discrete area, as well as the impact of workload/handling qualities factors with respect to selected airspeeds and differing levels of complexity. When addressing workload, the propensity for procedures to encourage errant deviations from intended flight path should also be considered.

SPECIAL IMPACT OF RELATIVE WIND must be evaluated for helicopter procedures. In the past, criteria have been used which were distinctly applicable to fixed wing operations. From the operational definition of the helicopter environment, an appropriate level of omnidirectional relative wind must be determined which will be applied to the calculation of lateral airspace requirements.

<u>Approach Areas and Segments</u>

The subject areas requiring data acquisition for this discrete area apply to both precision and non-precision approaches.

LATERAL AIRSPACE REQUIREMENTS call for application of system accuracy results from the Guidance System Accuracies discrete area, and determining any special effects of workload during approach segments.

VERTICAL AIRSPACE REQUIREMENTS will be determined by applying system accuracy results in combination with general descent performance and altitude control as appropriate. Descent gradients must be considered, especially those necessary in the procedure turn, as well as the special impact of FTE as it is impacted by such factors as: airspeed, rate of descent and glidepath angle. The determination of airspace requirements must be approached differently for the two types of approaches. The vertical requirements are angular for precision approaches and altitude-oriented for non-precision approaches.

FINAL APPROACH SEGMENT LENGTH must be determined. The operational requirements of the final approach segment must first be functionally defined. Then minimum and maximum segment lengths will be determined, especially with respect to such factors as: intercept angles, descent gradients, minimum time and distance required to become established on course and glideslope, and the sensitivity of cockpit indications.

NUMBER OF SEGMENTS REQUIRED must be determined by reviewing requirements and benefits of each segment, and then proposing and evaluating "economy-of-airspace" approach profiles as appropriate. The end result should include determination of optimum approach profiles for various guidance systems. The first step in determining the number of segments required will be to functionally define the operational requirements to prepare for the final approach.

EFFECT OF WIND SHEAR is especially important at low airspeeds, and it must be evaluated with respect to the critical aspects of power available. This will be a long-term effort, and will investigate the effects of wind shear to determine requirements for future testing. It should be noted that compensating for the effects of wind shear is done operationally and is not handled via obstacle clearance criteria.

Landing Minimums

This discrete area is involved with determination of visibility requirements as they relate to minimum descent altitude (MDA) and height above touchdown (HAT) minimums for approaches. The subject areas requiring data acquisition include:

MINIMUM DH must be determined as a function of reaction time at DH as affected by: actual versus reported visibility, cockpit cutoff angles, cockpit indications of arrival at DH, deceleration in visual conditions, and especially by aircrew manning level (single versus dual pilot).

VISIBILITY CREDITS for the effect of lighting and marking (night and day) on restriction to visibility. The investigation of visibility credits will include the impact of reduced transmissivity as well as credits for the enhancement of visual cues.

STEEP APPROACH REQUIREMENTS, especially the results of high descent rates, and particularly how steep approaches affect DH/HAT requirements.

DECELERATING APPROACH REQUIREMENTS under IMC will be determined on two levels. Near-term efforts will concentrate on defining the requirements for deceleration to those minimum IFR airspeeds currently certified. Long-term efforts will address requirements for more advanced approaches, i.e., the anticipated future operational desires for deceleration to zero groundspeed hover and/or touchdown.

SIZE OF APPROACH WINDOW AT MAP, which changes relative to distance from touchdown, lateral displacement of the FAC at the MAP, and the probability of being delivered within that window for a given range.

HELICOPTER LANDING CATEGORIES will be investigated, following the documentation of helicopter capabilities. Pertinent performance/maneuver capabilities of different helicopters must be compared to determine how many categories would be appropriate for helicopter approaches. In the

event that differences in performance capabilities lend themselves to establishing a number of landing categories for helicopters, the procedures and criteria to be developed for the TERPS Handbook will better be able to allow the utilization of helicopters to their practical maximum.

<u>Missed Approach</u>

This discrete area applies to both turning, straight, and combination missed approaches. Subject areas requiring data acquisition include:

LATERAL AIRSPACE REQUIREMENTS, especially the earliest point of effective course guidance, effects of maximum unknown winds, and the development of requirements for splay angles.

HEIGHT LOSS and its relationship to variations in rate of descent (descent angle and airspeed), technique of missed approach, and density altitude. Also required will be an investigation of the dependency of height loss on power available, and a determination of maximum allowable tailwinds. Operational considerations of missed approach will consider appropriate limiting G-factors during the maneuver.

MISSED APPROACH RATE analysis will be a long-term effort. The missed approach rate must be determined from the vicinity of DH for both shallow and steep approaches, and will be developed as the frequency of helicopter operations under IMC increases.

LONGITUDINAL DISTANCE TO REGAIN DH will need to be evaluated versus varying techniques during missed approach go-around, and the effects of power available and tailwinds, to determine appropriate locations of the origins of missed approach surfaces.

MISSED APPROACH CLIMB GRADIENT as affected by power available limitations, selected airspeeds, and climb performance.

MINIMUM MANEUVERING ALTITUDE, which is a special requirement for the "turn immediately" missed approach procedure, will be determined.

VERTICAL OBSTACLE CLEARANCE REQUIREMENTS will be determined by considering the displacement from height loss and the distribution of climb gradients and the longitudinal distance to regain DH.

Visual Approach Segment

Criteria and procedures for the visual approach segment are not specified in the TERPS Handbook. However, the requirements for this segment have a significant impact on the development of criteria and procedures for the final approach segment, and especially on placement of the DH or VDP.

As stated earlier, the TERPS Handbook has traditionally addressed only those operations under IMC, and has not concerned itself with the visual segments. It does, however, provide guidance and direction for developing instrument approaches which deliver a helicopter to a missed approach point from which an approach and landing is to be executed under VMC. Because the MAP should be such that it places the helicopter in a position from which that objective can be successfully met, it becomes important to define the requirements for the subsequent visual approach segment. The requirements for transition from IMC to VMC are discussed under General Performance Factors.

This section concentrates on those visual approach segment requirements which impact the placement of the DH or VDP. Further, the data requirements identified in this section are applicable almost exclusively to precision approaches because of the more critical nature of visual requirements for straight-in, precision approaches that hold out the possibility for low landing minimums. Non-precision approaches, which may or may not involve circling maneuvers, are addressed as a separate data requirement in this section.

Specifically, this discrete area addresses landing deceleration distances, maneuver requirements for the visual segment, special requirements from declerating approaches, and visual maneuvering areas.

LANDING DECELERATION DISTANCE requirements will include definition of VMC deceleration standards, especially determination of the time and distance to decelerate to a hover from selected airspeeds. Slant distances versus airspeeds must be documented while considering both helicopter deceleration capabilities and the appropriate deceleration rates acceptable to pilots.

VISUAL SEGMENT MANEUVER REQUIREMENTS must be known with respect to: turn requirements; the effects of various combinations of airspeeds, rates of descent, and altitudes (height above landing area); from different types of IMC final approach segments; impact of approach window size at the MAP; and especially their effect on landing minimums. The impact on visual segment maneuver requirements of final approach course (FAC) alignment variations and offset MAPs will also be investigated. One fundamental question to be answered is "Where does the visual approach segment begin?" This can be determined after the visual segment maneuver requirements are defined. The impact on criteria and procedures of various flight conditions (especially the interaction of aircraft attitude, rate of descent and airspeed) must be known, particularly on minimums. Also of concern is the impact of those flight conditions on steep approaches, with respect to the approach window size at the MAP.

SPECIAL REQUIREMENTS FROM DECELERATING APPROACHES will include effects of aircraft deceleration attitudes, and also the power requirements from Decision Height.

VISUAL MANEUVERING AREAS will also be determined, especially as they apply to circling maneuver requirements. This will consider the maneuvers that are desired or required during limited visibility VMC approaches, and will apply the distribution of descent gradients and turning radii for helicopters at various airspeeds and flight conditions.

General Performance Factors

Although this discrete area does not define a specific terminal phase of the helicopter IFR flight profile, it is equally important. Certain data must be generally applied across the board to all the discrete areas addressed in this program plan. These general data requirements must be applied equally to all performance-oriented data acquisiton efforts. These performance factors are discussed below, and the discrete areas which they most significantly impact are identified.

EFFECT OF RELATIVE WIND involves determining the most appropriate level of wind to be considered in computing its impact on flight phases. Discrete areas most significantly impacted by this data are: Takeoff and Takeoff Minimums, Approach Areas and Segments, and Missed Approach. More specifically, effects of winds will especially impact: most lateral airspace requirements, takeoff distance, climb gradients, descent gradients (with particular emphasis on settling with power considerations and ability to maintain glidepath), and height loss. Additionally, maximum tailwinds should be recommended for takeoff and approach/landing, the latter with respect to decision height and airspeed on final approach).

DENSITY ALTITUDE must be considered with respect to its impact on power available, height loss, settling with power, and retreating blade stall. The discrete areas most significantly impacted by density altitude data are: Takeoff and Takeoff Minimums, Approach Areas and Segments, Missed Approach, and Procedure Turn/Holding Areas.

EARLIEST POINT OF EFFECTIVE COURSE GUIDANCE will be derived from system accuracy determined in the Guidance System Accuracies data collection efforts. It is applied across the board here as a general data requirement to allow for its special impact in certain areas on lateral and vertical guidance. The discrete areas most significantly impacted by this data are: Departure and Missed Approach.

IMPACT OF WORKLOAD/HANDLING QUALITIES FACTORS will determine the impact of a number of variables, such as: aircrew manning level, the degree of stability augmentation, level of automation (manual versus coupled) where appropriate, environmental conditions, and other workload factors. The discrete areas most significantly impacted by this requirement are: Takeoff and Takeoff Minimums, Procedure Turn/Holding Areas, Approach Areas and Segments, and Missed Approach. Normal review efforts of TERPS includes an assessment of the potential for errant deviations of any procedure. Any new procedures developed under this program will be reviewed for its propensity to encourage errant deviations. Any proposed procedure which is considered conducive to a high workload situation will be identified as an item for special evaluation during both flight simulation testing and operational validation. This will help assure both the practicality and flyability of future helicopter TERPS.

CRITICAL ASPECTS OF SLOW SPEED FLIGHT must be investigated seriously if the helicopter industry continues to move toward maximum application of helicopter capabilities. Most importantly, the critical aspects must be examined as they apply to IMC flight. The discrete areas most significantly impacted by this data are: Takeoff and Takeoff Minimums, Approach Areas and Segments, and Missed Approach. More specifically, the data has critical impact on: takeoff profiles, missed approach procedures, low altitude wind shear effects, and contributes to the impact of workload/handling qualities factors. Investigation of this helicopter-unique flight regime will require a thorough documentation of their slow speed flight characteristics. Present airspeed systems become unreliable at speeds below 25 to 30 knots, and are undesirable by most pilots' standards at indicated speeds of less than 50 knots. To properly investigate this airspeed range, an indicating system should be installed on the flight test vehicle which is capable of accurately measuring airspeed and relative wind to zero knots, while simultaneously indicating the direction of the relative wind.

INSTRUMENTATION/DISPLAY REQUIREMENTS is effectively a consideration in the workload/handling qualities factors evaluation, and can greatly impact all phases of the IFR flight profile. This requirement here is concerned largely with determining the requirements for instrumentation and display for pilots where appropriate for specific flight tasks. The discrete areas most significantly impacted by this requirement are: Takeoff and Takeoff Minimums, Approach Areas and Segments, and Missed Approach. Moreover, it has critical impact on the missed approach go-around and also on the visual approach segment when environmental conditions are less than optimum.

EFFECT OF FLIGHT ENVELOPE TAILORING involves documentation of the performance envelopes for IFR-certified helicopters. When a helicopter is certified for IFR operation by the FAA, the approved rotorcraft flight manual prescribes, among other things, minimum and maximum airspeeds. This is one instance of envelope tailoring. Other examples which have occurred include establishing maximum allowable rates of descent and, in one recent case, maximum permissible rates of climb. The impact of this on terminal instrument procedures is reflected in the change in capability of a helicopter to execute certain maneuvers. Both IMC and VMC airspeed envelopes will be documented for currently certified helicopters, especially to identify certification envelope tailoring (limitations/constraints) and the airspeeds for such items as: maximum rate of climb, recommended rate of climb, maximum rate of descent, etc. Also, Height-Velocity requirements should be considered for both IMC and VMC operations where they are applicable.

IMC/VMC TRANSITION REQUIREMENTS are more critical than the VMC/IMC transition which follows takeoff. At takeoff, the pilot has a clear idea of what to expect on transition into IMC and is reasonably well prepared for the brief adjustment period. However, for transition from IMC to VMC at breakout, there is a definite anticipation of the unknown. The pilot must be prepared for a number of possible combinations of restrictions to visibility and ambient light conditions. He must also respond to maneuver requirements, which are unknown while still in the clouds, for the physical position at time of breakout. The restrictions to visibility could be

varying intensities of rain, drizzle or fog which may be more severe because of airspeed. Ambient light levels could be brighter or darker than what he has become accustomed to in the clouds, or in the darkness of night IMC there may be an unsettling effect of sudden transition to lights. Unknown maneuver requirements compound the issue, since the pilot will not know until breakout exactly what his alignment will be to the landing area. Will he need to perform a sidestep to the right or the left? Will that be aggravated by delays in recognition caused by poor visibility? Will he trust the first impression from visual cues and react? If not, how long will he take to satisfy himself that he has correctly interpreted his position using available visual cues? Further, when landing in remote areas, the transition could be even more difficult if visual cues are limited (such as a "black hole" approach to a point-in-space).

SECTION 4
DATA COLLECTION EFFORTS

Introduction

This section introduces the on-going and planned projects which will provide data to the program, shows how they will be applied, and presents a milestone schedule for those data collection efforts which are considered near-term. Descriptions of each project are contained in the Appendix.

The data requirements necessary in developing helicopter TERPS were identified in Section 3 for nine discrete areas of TERPS. The projects from which that data will be derived are numerous, and involve both near-term and long-term projects. Most of those data collection efforts will provide data to more than one discrete area. Figure 4-1 (Overview of Sources of Data for Discrete Areas) identifies the discrete areas for which each project (data collection effort) is expected to provide data. Figures 4-2 through 4-10 address each discrete area in greater detail. For each discrete area, the specific data requirement areas are listed, and projects which are a source of data for that requirement area is identified in the matrix. In the event that available projects cannot fully satisfy a data requirement area then additional projects will be proposed to fill any voids in data.

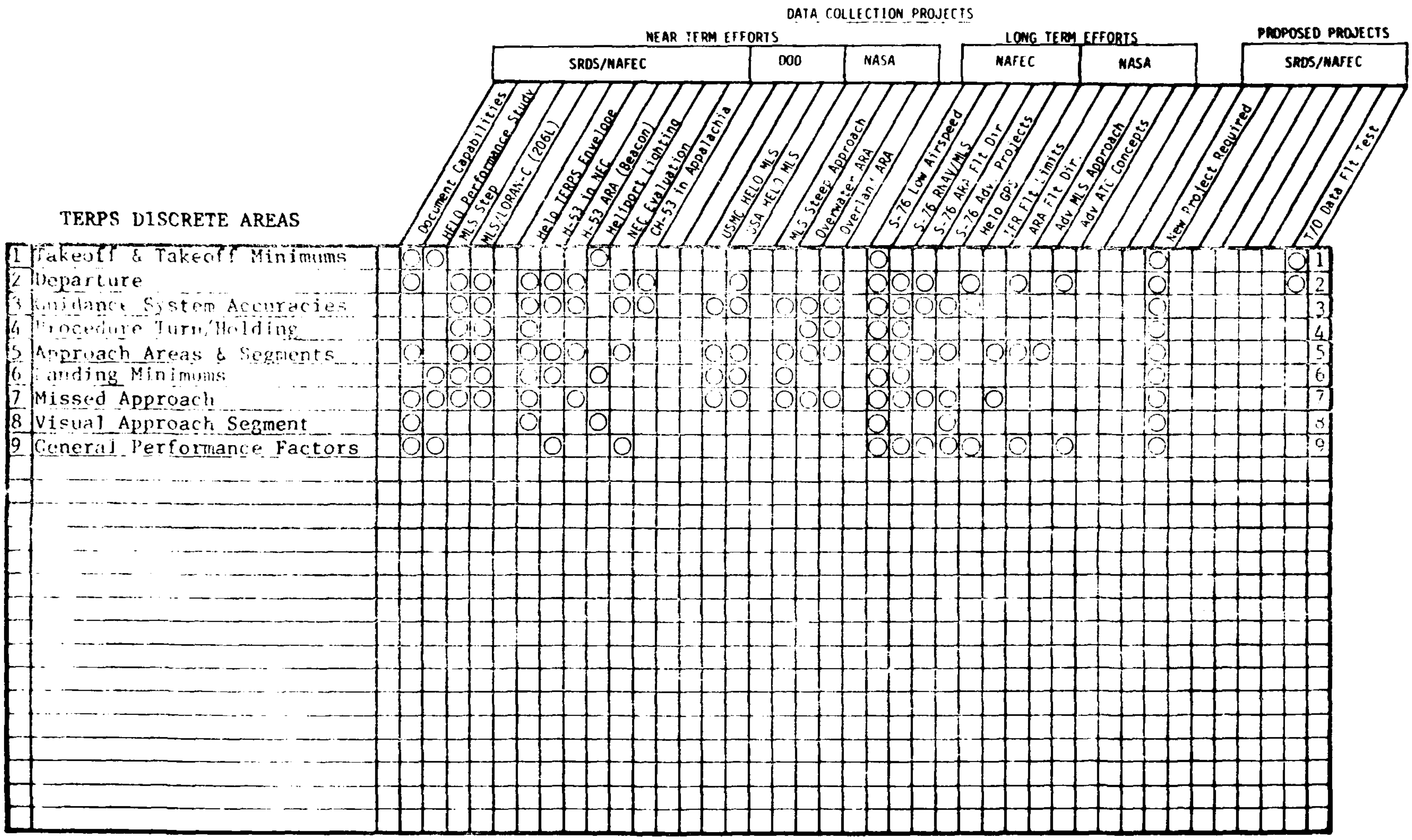


Figure 4-1. Overview of Sources of Data for Discrete Areas.

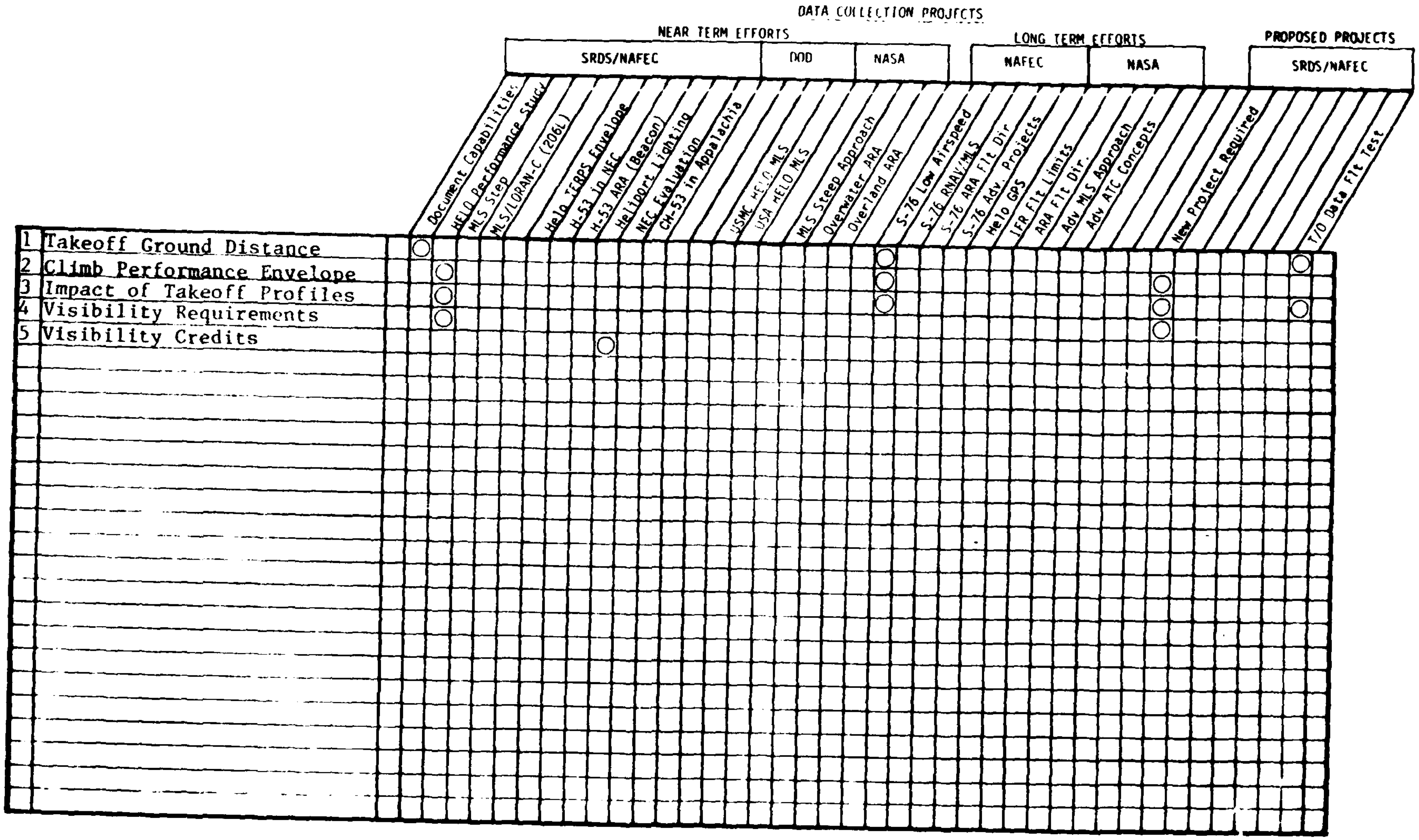


Figure 4-2. Sources for Takeoff and Takeoff Minimum Data.

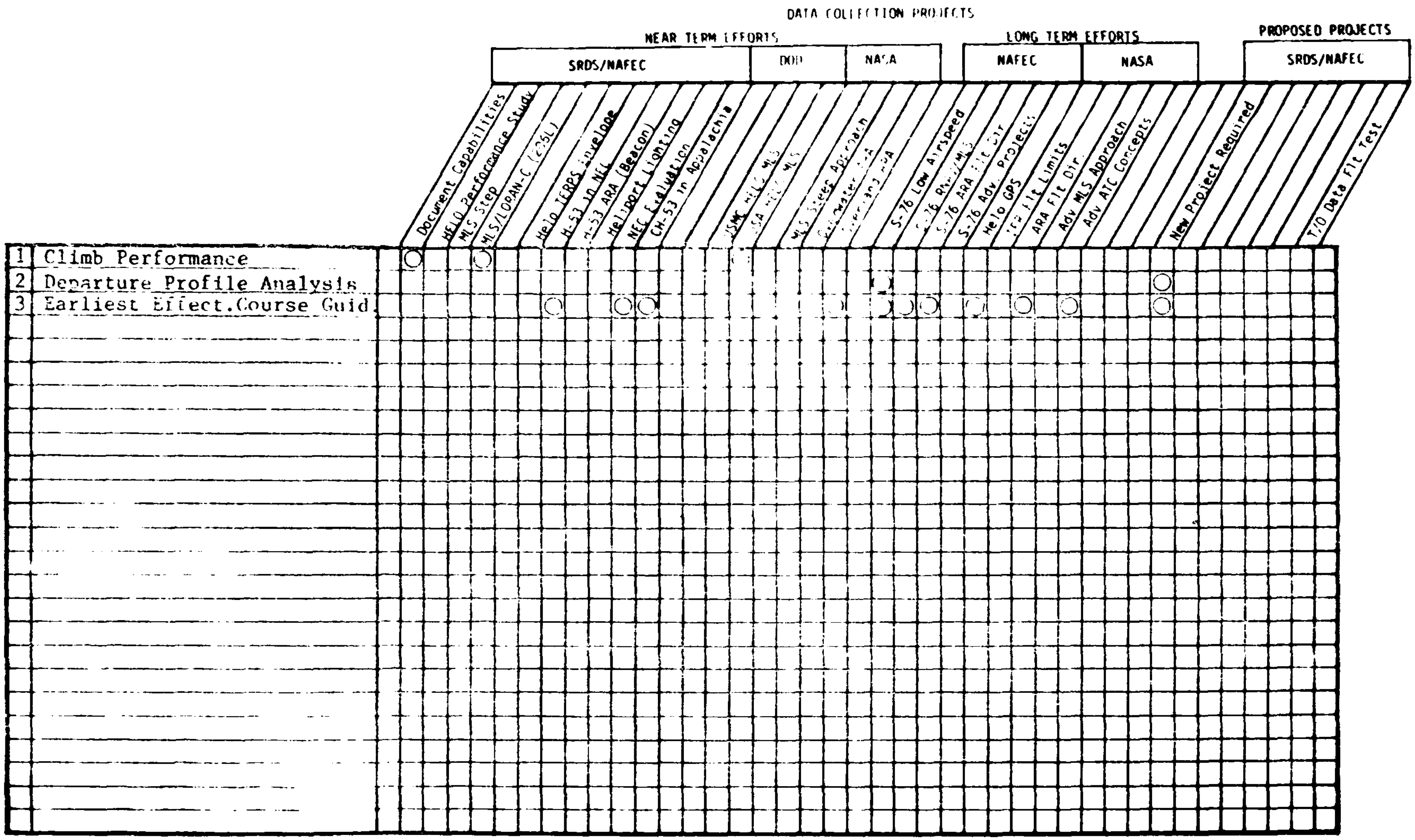


Figure 4-3. Sources for Departure Data.

DATA COLLECTION PROJECTS

	NEAR TERM EFFORTS – SRDS/NAFEC										NEAR TERM EFFORTS – DOD		NEAR TERM EFFORTS – NASA			LONG TERM EFFORTS – NAFEC					LONG TERM EFFORTS – NASA				PROPOSED PROJECTS – SRDS/NAFEC	
	Document Capabilities	HELO Performance Study	MLS Step	MLS/LORAN-C (206L)	Helo TERPS Envelope	H-53 in NEC	H-53 ARA (Beacon)	Heliport Lighting	NEC Evaluation	CH-53 in Appalachia	USMC HELO MLS	USA HELO MLS	MLS Steep Approach	Overwater ARA	Overland ARA	S-76 Low Airspeed	S-76 RNAV/MLS	S-76 ARA Flt Dir	S-76 Adv. Projects	Helo GPS	IFR Flt Limits	ARA Flt Dir.	Adv MLS Approach	Adv ATC Concepts	New Project Required	T/O Data Flt Test
1 Ground System Error																										
a) ILS				O	O																					
b) MLS			O								O	O	O				O						O			
c) VOR					O	O			O	O							O									
d) DME					O	O			O	O							O									
e) NDB					O																					
f) LORAN-C				O		O				O									O			O				
g) VLF/OMEGA						O																				
h) ARN															O										O	
i) ARA							O							O	O			O	O							
j) GPS										O										O						
2 Flight Technical Error					O	O	O				O	O	O	O	O	O	O									
3 Airborne System Error			O	O																					O	
4 Point of Earliest Eff. Guid.			O	O	O	O	O		O		O	O	O	O	O	O	O	O	O	O		O	O			

Figure 4-4. Sources for Guidance System Accuracies Data.

DATA COLLECTION PROJECTS

		NEAR TERM EFFORTS – SRDS/NAFEC: Document Capabilities	NEAR TERM EFFORTS – SRDS/NAFEC: HELO Performance Study	NEAR TERM EFFORTS – SRDS/NAFEC: MLS Step	NEAR TERM EFFORTS – SRDS/NAFEC: MLS/LORAN-C (206L)	NEAR TERM EFFORTS – SRDS/NAFEC: Helo TERPS Envelope	NEAR TERM EFFORTS – SRDS/NAFEC: H-53 in NEC	NEAR TERM EFFORTS – SRDS/NAFEC: H-53 ARA (Beacon)	NEAR TERM EFFORTS – SRDS/NAFEC: Heliport Lighting	NEAR TERM EFFORTS – SRDS/NAFEC: NEC Evaluation	NEAR TERM EFFORTS – SRDS/NAFEC: CH-53 in Appalachia	NEAR TERM EFFORTS – DOD: USMC HELO MLS	NEAR TERM EFFORTS – DOD: USA HELO MLS	NEAR TERM EFFORTS – NASA: MLS Steep Approach	NEAR TERM EFFORTS – NASA: Overwater ARA	NEAR TERM EFFORTS – NASA: Overland ARA	LONG TERM EFFORTS – NAFEC: S-76 Low Airspeed	LONG TERM EFFORTS – NAFEC: S-76 RNAV/MLS	LONG TERM EFFORTS – NAFEC: S-76 ARA Flt Dir	LONG TERM EFFORTS – NAFEC: S-76 Adv. Projects	LONG TERM EFFORTS – NAFEC: Helo GPS	LONG TERM EFFORTS – NASA: IFR Flt Limits	LONG TERM EFFORTS – NASA: ARA Flt Dir.	LONG TERM EFFORTS – NASA: Adv MLS Approach	LONG TERM EFFORTS – NASA: Adv ATC Concepts	PROPOSED PROJECTS – SRDS/NAFEC: New Project Required	PROPOSED PROJECTS – SRDS/NAFEC: T/O Data Flt Test
1	Lateral Airspace Rqmts.			O	O	O		O							O	O		O									
2	Vertical Airspace Rqmts.					O									O	O											
3	Evaluate Patterns & Turns																O									O	
4	Impact of Relative Wind																									O	

Figure 4-5. Sources for Procedure Turn/Holding Area Data.

DATA COLLECTION PROJECTS

		NEAR TERM EFFORTS: SRDS/NAFEC										NEAR TERM EFFORTS: DOD		NEAR TERM EFFORTS: NASA			LONG TERM EFFORTS: NAFEC					LONG TERM EFFORTS: NASA				PROPOSED PROJECTS: SRDS/NAFEC	
		Document Capabilities	HELO Performance Study	MLS Step	MLS/LORAN-C (206L)	Helo TERPS Envelope	H-53 in NEC	H-53 ARA (Beacon)	Heliport Lighting	NEC Evaluation	CH-53 in Appalachia	USMC HELO MLS	USA HELO MLS	MLS Steep Approach	Overwater ARA	Overland ARA	S-76 Low Airspeed	S-76 RNAV/MLS	S-76 ARA Flt Dir	S-76 Adv. Projects	Helo GPS	IFR Flt Limits	ARA Flt Dir.	Adv MLS Approach	Adv ATC Concepts	New Project Required	T/O Data Flt Test
1	Lateral Airspace Rqmt.			O	O	O	O	O		O			O	O	O	O		O	O	O			O				
2	Vertical Airspace Rqmt.	O		O	O							O	O	O	O			O				O					
3	Final Appr. Segment Length																O										
4	No. of Segments Required			O	O							O	O	O				O				O		O			
5	Effect of Wind Shear																									O	

Figure 4-6. Sources for Approach Areas and Segments Data.

DATA COLLECTION PROJECTS

NEAR TERM EFFORTS — SRDS/NAFEC

	Document Capabilities	HELO Performance Study	MLS Step	MLS/LORAN-C (206L)	Helo TERPS Envelope	H-53 in NEC	H-53 ARA (Beacon)	Heliport Lighting	NEC Evaluation	CH-53 in Appalachia
1 Minimum DH		O	O	O	O	O				
2 Visibility Credits								O		
3 Steep Approach Rqmts.		O	O							
4 Decelerating Approach Rqmts.										
5 Size of Approach Window@MAP		O	O		O					
6 Helo Landing Categories										

NEAR TERM EFFORTS — DOD and NASA

	DOD: USMC HELO MLS	DOD: USA HELO MLS	NASA: MLS Steep Approach	NASA: Overwater ARA	NASA: Overland ARA
1 Minimum DH	O	O	O		
2 Visibility Credits					
3 Steep Approach Rqmts.	O		O		
4 Decelerating Approach Rqmts.		O			
5 Size of Approach Window@MAP			O		
6 Helo Landing Categories					

LONG TERM EFFORTS — NAFEC and NASA

	NAFEC: S-76 Low Airspeed	NAFEC: S-76 RNAV/MLS	NAFEC: S-76 ARA Flt Dir	NAFEC: S-76 Adv. Projects	NAFEC: Helo GPS	NAFEC: IFR Flt Limits	NASA: ARA Flt Dir	NASA: Adv MLS Approach	NASA: Adv ATC Concepts
1 Minimum DH	O	O							
2 Visibility Credits									
3 Steep Approach Rqmts.	O								
4 Decelerating Approach Rqmts.	O	O							
5 Size of Approach Window@MAP	O								
6 Helo Landing Categories									

PROPOSED PROJECTS — SRDS/NAFEC

	New Project Required	T/O Data Flt Test
1 Minimum DH		
2 Visibility Credits	O	
3 Steep Approach Rqmts.		
4 Decelerating Approach Rqmts.		
5 Size of Approach Window@MAP	O	
6 Helo Landing Categories	O	

Figure 4-7. Sources for Landing Minimums Data.

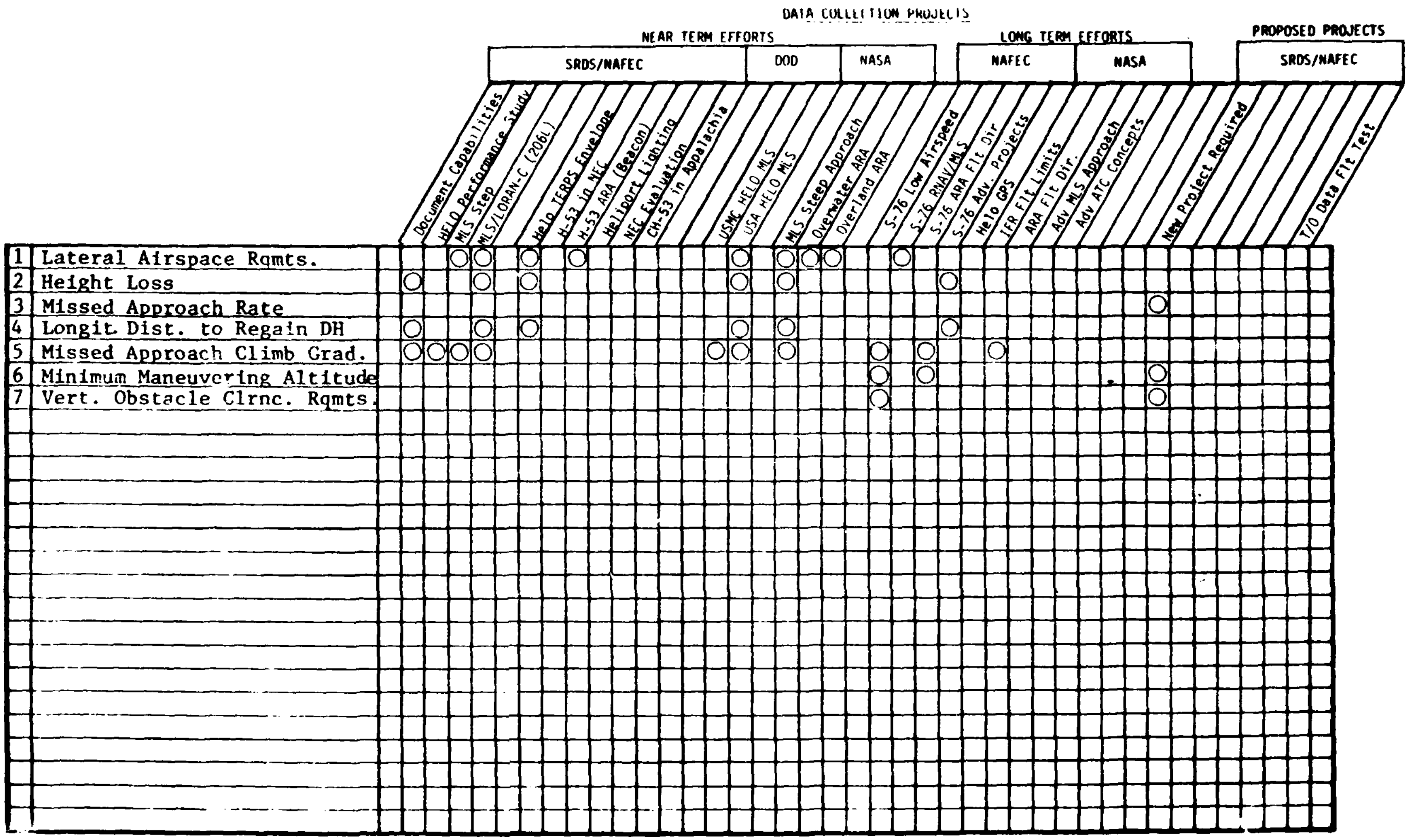


Figure 4-8. Sources for Missed Approach Data.

DATA COLLECTION PROJECTS

NEAR TERM EFFORTS

		SRDS/NAFEC										DOD		NASA		
		Document Capabilities	HELO Performance Study	MLS Step	MLS/LORAN-C (206L)	Helo TERPS Envelope	H-53 in NEC	H-53 ARA (Beacon)	Heliport Lighting	NEC Evaluation	CH-53 in Appalachia	USMC HELO MLS	USA HELO MLS	MLS Steep Approach	Overwater ARA	Overland ARA
1	Landing Decel. Distance	O														
2	Visual Segment Maneuver Rqmt															
3	Decelerating Approach Rqmts.								O							
4	Visual Maneuvering Areas															

LONG TERM EFFORTS / PROPOSED PROJECTS

		NAFEC (Long Term Efforts)						NASA (Long Term Efforts)			SRDS/NAFEC (Proposed Projects)
		S-76 Low Airspeed	S-76 RVAV/MLS	S-76 ARA Flt Dir	S-76 Adv. Projects	Helo GPS	IFR Flt Limits	ARA Flt Dir.	Adv MLS Approach	Adv ATC Concepts	New Project Required	T/O Data Flt Test
1	Landing Decel. Distance	O			O							
2	Visual Segment Maneuver Rqmt	O			O						O	
3	Decelerating Approach Rqmts.	O			O							
4	Visual Maneuvering Areas	O									O	

Figure 4-9. Sources for Visual Approach Segment Data.

DATA COLLECTION PROJECTS

	NEAR TERM EFFORTS: SRDS/NAFEC										NEAR TERM EFFORTS: DOD		NEAR TERM EFFORTS: NASA			LONG TERM EFFORTS: NAFEC					LONG TERM EFFORTS: NASA				PROPOSED PROJECTS: SRDS/NAFEC	
	Document Capabilities	HELO Performance Study	MLS Step	MLS/LORAN-C (206L)	Helo TERPS Envelope	H-53 in NEC	H-53 ARA (Beacon)	Heliport Lighting	NEC Evaluation	CH-53 in Appalachia	USMC HELO MLS	USA HELO MLS	MLS Steep Approach	Overwater ARA	Overland ARA	S-76 Low Airspeed	S-76 RNAV/MLS	S-76 ARA Flt Dir	S-76 Adv. Projects	Helo GPS	IFR Flt Limits	ARA Flt Dir.	Adv MLS Approach	Adv ATC Concepts	New Project Required	T/O Data Flt Test
1 Effect of Relative Wind	O	O														O									O	
2 Impact of Density Altitude	O	O																							O	
3 Earliest Effec. Course Guid.						O			O						O	O	O	O				O		O	O	
4 Impact of Workload/Hq Factor		O														O									O	
5 Critical Aspects of Slow Speed Flight																O									O	
6 Instrumentation/Display Requirements		O														O			O						O	
7 Flight Envelope Tailoring	O															O										

Figure 4-10. Sources for General Performance Factors Data.

Near-Term Data Collection Efforts

The near-term efforts were defined as those which will provide data to the program by the end of 1980. They are expected to satisfy enough of the data requirements to enable Flight Operations to conduct an initial review of the following areas:

- o Takeoff Minimums
- o Holding Patterns
- o Landing Minimums
- o Missed Approach Areas
- o Surfaces for VOR, NDB, ILS, Loran-C

The projects that comprise the near-term program efforts are listed in Figure 4-11 (Major Milestones, Near-Term Data Collection Efforts). It shows when data will be available from each of the projects for application to the subject areas addressed above.

Long-Term Data Collection Efforts

The long-term efforts will attempt to complete the data acquisition for those discrete TERPS areas not accomplished in the near-term. Data derived from these efforts are expected to allow revisions to procedures in Chapter 11 of the TERPS Handbook.

Further, the effort is expected to identify appropriate study requirements for the future to permit advanced evolution of terminal and enroute procedures and criteria for instrument operation of helicopters.

Helicopter TERPS Development Program

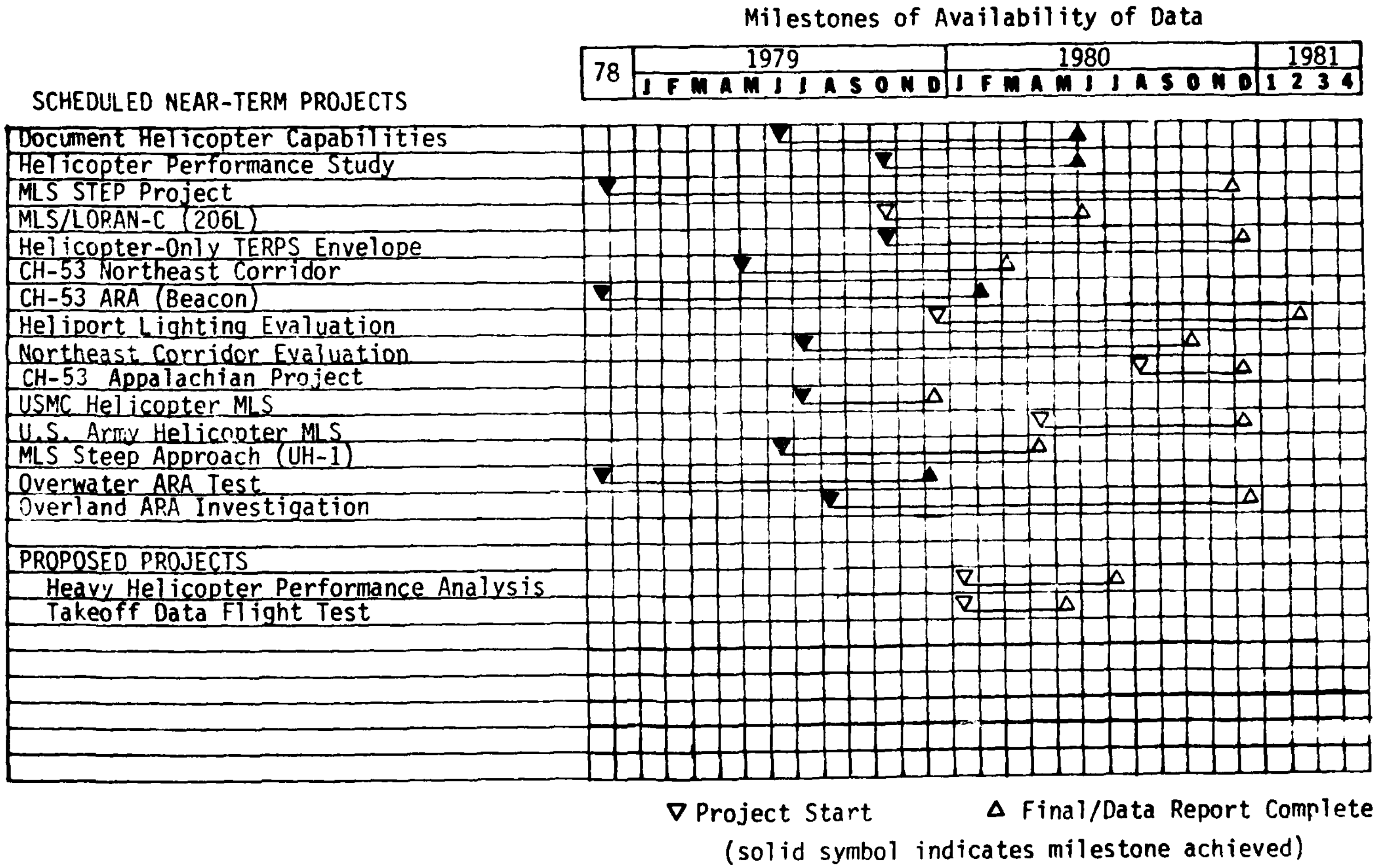


Figure 4-11. Major Milestones, Near-Term Data Collection Efforts.

Advanced-Term Data Collection Efforts

Advanced-term projects will respond to study requirements identified through the long-term projects. It is recognized that many of the future requirements must await technological advances which will make necessary capabilities available to the helicopter community. One consideration is that certification standards will need to be established for aircraft, subsystems and components relative to such items as low-range airspeed systems, autopilots with coupled decelerating approach capability, and more.

APPENDIX

DESCRIPTION OF DATA COLLECTION EFFORTS

Data from a number of on-going and planned flight experiments, simulation exercises, and other projects and data collection efforts will be applied during this program. The individual data collection projects which were identified in the program plan are described in this appendix.

Because the number of projects being coordinated under this program are numerous, the following page contains Table A-1: Index to Data Collection Projects which are contained in this appendix.

TABLE A-1

INDEX TO DATA COLLECTION PROJECTS

Document Helicopter Capabilities

Objective is to acquire data base on the operational capability of IFR helicopters. Study will document the maneuver-performance capability of helicopters. Data will be utilized to establish parametric envelopes that can be applied by Flight Operations in reviewing helicopter instrument procedures.

Helicopter Performance Study

Objective is to establish parametric IFR envelopes of helicopter capabilities that can be applied by Flight Operations in reviewing terminal and enroute instrument procedures for helicopters.

Study will review and analyze data received from the Documentation of Helicopter Capabilities above. This data will be provided to Flight Operations for use in updating the procedures and criteria of Chapter 11 of the TERPS Handbook so as to be based upon helicopter capabilities rather than fixed wing.

MLS STEP Project

Objectives are development, validation and refinement of operational, technical, and support concepts which utilize the unique attributes of MLS to optimize user benefits and minimize costs.

This is the STEP (Service Test and Evaluation Program) currently being conducted by FAA at major airfields primarily in the Northeastern United States, using real-world operations and commercial operators as a test bed. In Phase I, six or seven existing ground stations are to be used principally by commuter-type commercial operators during routine operations. Phase II expands the number of ground transmitter installations by approximately 15 additional units, and airborne receivers by 33 units.

MLS/Loran-C (BH-206L) Test

Objectives are to document accuracy of MLS and Loran-C systems; document capabilities of a light helicopter using MLS approach guidance system; orientation of FAA personnel to helicopter capabilities; develop preliminary performance data for selected helicopter TERPS capabilities.

Bell 206L LongRanger used by FAA Headquarters will be flown under simulated IMC flight conditions. MLS and Loran-C will be time-shared (i.e., one system installed at a time). A recorder package and rack will be fitted to permit quick installation for testing periods, and removal during other helicopter use. The helicopter will be scheduled for several days at a time for flight testing at NAFEC, and will be flown between DCA and NAFEC.

Information on flight technical error will be derived during MLS approaches to DCA, and Loran-C navigation. Further work with MLS will be done at NAFEC using their ground-tracking equipment. Performance data will be collected on observed height loss at Decision Height and on rates of climb and descent for various airspeeds at selected gross weights. Flight technical error will also be documented on turning missed approach following a precision approach.

Helicopter-Only TERPS Envelope

Objective is to expand the obstruction clearance data base for various helicopters in the real-world instrument environment. A portable, ground-based, radar unit will be used to track helicopter operations in the Gulf Coast by recording azimuth, elevation, distance and ground speed. Equipment has a tracking range of 15-20 miles for aircraft at altitudes as low as 100-150 ft. AGL.

The radar unit does not require cooperative targets and involves no modification to target helicopters. It will be used to measure total system performance of helicopters during approaches, and will include performance during some initial and intermediate approach segments. Project will track helicopters in the Gulf Coast area while they are conducting routine terminal operations to on-shore facilities. Navaids

used will be NDB, VORTAC and ILS. The subject helicopter activities will include local instrument training, Sikorsky S-76 transitions, and UH-1H helicopters flown by the Army National Guard.

CH-53 Northeast Corridor Project

Objectives are evaluation of the following navigation and approach systems to determine their suitability for low-level helicopter operations; and to collect data for use in developing terminal approach procedures and defining airspace requirements: VOR/DME, NDB, Loran-C, VLF/Omega and Airborne Weather/Mapping Radar.

Project involves flight tests of operations in the Northeast Corridor (90 flight hours, combined with Loran-C approach evaluations); ARA enroute tests; ARA dual beacon-skin paint mode tests (8 hours); and modification of a radar display to indicate approach course line (18 hours). The latter (approach course line) displays data from three nav systems simultaneously (VOR/DME, Loran-C, VLF/ Omega).

CH-53 Airborne Radar Approach (Beacon) Project

Objective is to provide data base to support development of airborne radar approach procedures. Project involves flight evaluation by NAFEC pilots of airborne radar approaches with beacon to remote areas and oil rigs in the Delaware Bay area. Flight tests have been completed. Data from these tests combined with data from the overwater ARA tests will be used to support preparation of an overwater ARA Advisory Circular.

Heliport Lighting Evaluation

Objective is to develop design criteria for visual guidance systems intended to support helicopter IFR approach and landing operations to all-weather heliports. Project will study helicopter visual aids presently in use. The best features of these systems will be incorporated into a comprehensive lighting and marking system to be installed at NAFEC's heliport for testing and evaluation. The heliport is scheduled for completion in May 1980 with flight tests on IFR lighting commencing in June. Results will be used to develop design criteria of a system for adoption as a U.S. Standard IFR Heliport Visual Guidance System.

Northeast Corridor (NEC) Evaluation

Objectives are evaluation of four-mile route width for helicopter operations; validation of operations along the Northeast Corridor (NEC) to allow it to become a permanent part of the ATC structure; provide data for implementation of similar type routes elsewhere within the National Airspace System; develop operational requirements for helicopters to be used in developing ATC systems and services for immediate and future needs of helicopters.

Commercial helicopter operators currently using the NEC will be studied to provide data. Sources of data include: radar position data of NEC operations derived from routine ATC facilities investigating Mode C/Transponder configured helicopters (information includes ground speed, altitude and horizontal position); also, user comments and flight logs collected through HAA.

CH-53 Appalachian Project

Objective is to evaluate Loran-C and communication patterns in the Appalachian area. NAFEC flight tests will be coordinated with the Appalachian Helicopter Pilots Association. Initial flights will take Loran-C and communication measurements. In addition, site surveys will be conducted to determine feasibility of establishing an experimental communication repeater station.

USMC Helicopter MLS Project

Objective is to develop helicopter performance data for MLS-type approaches. The USMC evaluation of MRAALS approach guidance system (with MLS-type capability, i.e., variable azimuth and glideslope) will be monitored to derive additional helicopter performance data during MLS-type operations. Ground-based laser tracking unit will document the performance of helicopters used in the test. Helicopter Systems Branch will solicit "man-machine performance" data which may be obtained from the project.

U.S. Army Helicopter MLS Project

Objectives are to record and analyze helicopter performance during MLS approaches; develop data for MLS obstruction clearance data; and assess the

benefits of flight director decelerating approaches. The Army UH-1 is equipped with an MLS, recording instrumentation and flight director.

This Army/NAFEC project will supplement and complement the MLS flights at NASA-Ames. The NASA data matrix was based upon the Basic Narrow MLS ($\pm$ 40° coverage) and landing site about 4000 ft. from the azimuth. These flights will use the Basic Wide MLS ($\pm$ 60° coverage), the Small Community ($\pm$ 10° coverage) and the Small Community co-located (azimuth and elevation at the same site) serving a heliport. Subject pilots will fly both manual and flight director approaches on 3°, 6° and 9° glideslopes. Steep angle MLS offset approaches will also be conducted at NAFEC's heliport facility.

MLS Steep Approach Evaluation

Objectives are to record and analyze helicopter performance during steep glideslope approaches at varying airspeeds; develop accuracy data on MLS receiver; and develop data for MLS obstruction clearance criteria.

Project involves steep angle approaches which are being conducted with a NASA-Ames UH-1H helicopter equipped with MLS. Raw data is presented to the pilot in the same fashion as the traditional course deviation indicator presently used for ILS approaches. The MLS provides pilot-selectable elevation (glideslope) and azimuth (localizer). Testing includes 3, 6 and 9 degree glideslopes. Data from this project will be used by the FAA for the MLS obstruction plane data base, and will be applied in the development of criteria and procedures for MLS approaches for helicopters.

Overwater ARA Test

Objectives are to develop airborne radar approach procedures; measure tracking errors; determine acceptable weather minimums; and determine pilot acceptability. Flight tests included overwater ARA approaches in the Gulf of Mexico using civilian pilots flying a Bell 212. Data is being used to support overwater ARA Advisory Circular.

Overland ARA Investigation

Objectives are to obtain radar signal characteristics on primary, beacon, and reflector returns during airborne radar approaches over various types of terrain; support NASA-Ames radar simulation program; and to

support the ARA/Flight Director program. This is an exploratory program in which the NASA-Ames SH-3A will fly about 75 hours, conducting approaches to various types of terrain, i.e., San Francisco Bay (coastal terrain), Crow's Landing (flat, improved terrain), San Joaquin Valley (flat, unimproved terrain), and Diablo Mountain Range (mountainous terrain). Loran-C will also be investigated.

Specific Areas and Problems

In near term, specific areas will have flight evaluations addressing navigation coverage, accuracy and procedures. Airborne equipment limitations will be addressed by improvements, such as RNAV software, initially augmented receiver-filters and improved antennas. Areas of immediate interest are Loran-C in Appalachia, Northeast corridor and Gulf of Mexico.

S-76 Low Airspeed Project

A low airspeed measurement system will be installed in the S-76 helicopter. Preliminary assessments will be made of the potential to improve helicopter operation efficiency and safety. Later the system will be configured for further testing of flight simulator developed minimum and advanced concepts of low speed IMC operations.

S-76 RNAV/MLS Evaluation Project

Objective is to evaluate MLS approaches using area navigation (RNAV) point-in-space as a combined approach aid. FAA's S-76 will be outfitted with MLS, RNAV, Airborne Weather Radar, and Loran-C. Flight testing will concentrate on evaluation of RNAV/MLS approaches using an RNAV point-in-space on the final MLS approach segment that can be either the missed approach point, or the final approach fix, or both. The majority of flight testing will be done at NAFEC, with some work conducted at DCA. An R-Nav computer operating from either VOR/DME or MLS/DME will be integrated with a color radar so the routing overlays the radar presentation. This configuration will be evaluated for major terminals and in remote areas in conjunctions with beacons and reflecters for radar target identification and enhancement.

S-76 Airborne Radar Approach/Flight Director Project

Objective is the improvement of airborne radar approach performance and pilot workload. Project involves modification/addition to the airborne radar in the S-76, and target identification by joystick input with improved displays. Elevation coded beacon replies will be considered.

S-76 Advanced Projects

Objective is to provide operational performance data through flight test and evaluation to support development of revised criteria and procedures for Chapter 11 of the TERPS Handbook. S-76 helicopter will be instrumented for investigation of low-level helicopter operations in high-density ATC areas. Operations will be conducted over proposed helicopter routes to investigate navigational coverage and accuracy and ATC interface problems in the TERPS environment.

IFR Flight Limitations

Objective is to establish safe operating envelopes for helicopter flight in the terminal environment under instrument conditions relative to airspeed, angle-of-bank, climb and descent rates, and visibility requirements. For this project, NASA-Ames has been requested to determine parameters through simulation for the following helicopter flight regimes: minimum approach speed; glideslope; radius of turn; forward visibility versus airspeed; transitional height loss; course deviation sensitivity; visual cues for Point-in-Space approaches; holding pattern airspace requirements.

ARA Flight Director Project

Objectives are to develop flight director commands derived from airborne radar data; and attempt to achieve single-pilot operation for ARA. Helicopter flight tests will be supported by a simulation program which generates airborne weather radar displays for use in a simulator. A Norden PDP 11/34M mini-computer will process radar information and generate flight director commands. And an actual flight director system will be developed for installation in the flight test helicopter (prime test vehicle). In an attempt to achieve single pilot operation for ARA, the

program will utilize computer assisted target identification, image enhancement techniques, and automated radar operation.

Advanced MLS Approach Concepts

Objectives are to provide performance data on MLS inputs for a flight director with DME inputs; and to develop the capability for spiral approaches under zero-zero conditions. Tests will be conducted at Crow's Landing utilizing NASA-Ames' UH-1H. MLS approach accuracy using a flight director in combination with DME will be documented. The project will also utilize MLS guidance with an on-board computer and multi-function display in an attempt to achieve the capability of spiral approaches that terminate with an automatic landing under zero visibility conditions.

Advanced ATC Concepts

Objective is development of the most promising air traffic control concepts for helicopters, using distributed management techniques. This project is in response to proposals for distributed management concepts between ground systems and airborne participants. Concepts will be formulated, simulated and evaluated against a 1985-type ATC scenario. Scenarios to be evaluated include pilot monitoring modes, and pilot cooperative modes such as lock-on and merging traffic assistance with assurance/confidence considerations. When utilizing in-house mini-simulation capabilities at NASA-Ames, FAA will provide ATC scenarios and controllers for experiments.

Full system testing will tie-in the Ames flight simulators to the ATC simulator at NAFEC, for an ATC simulation of JFK International Airport area, and will use several cabs for piloted/manned simulators. Concepts suitable for flight evaluation will be developed based on simulation exercises. Operational validation of the concepts developed from the full system testing will be accomplished using the FAA S-76 helicopter.

Helicopter GPS Evaluation

Objective is to evaluate the use of Global Positioning System (GPS) receivers by helicopters. A NAVSTAR GPS receiver will be installed for flight test work on FAA's helicopter at NAFEC. The GPS receiver will be installed to collect data and experience as an additional effort while

collecting other data such as Loran-C, ARA and RNAV. Studies will also be conducted to determine the potential for using a "differential" GPS concept to achieve suitable guidance accuracy for conducting helicopter approaches in remote areas.

Takeoff Data Flight Test (Proposed)

Objective is to obtain the specific takeoff data necessary for evaluation and review of takeoff minimums, real estate requirements, and surfaces for takeoff and departure.

Flight test will collect data applicable to helicopter-only (especially remote area) takeoffs and departures. Time and distance will be recorded for accelerations to selected airspeeds; and military instrument takeoff procedures will be evaluated to determine applicability of obstacle clearance surfaces. Flight tests are expected to utilize a UH-1H helicopter.